Suggestions to Teachers.

THE EARTH AS A PLANET.

To make the quadrant instrument to be used for measuring altitudes in Exercises I. and IV.: Make a quadrant circle of cardboard, or better, of tin, with a radius of about three inches. (Fig. I.) With a protractor mark the degrees and number every fifth degree. Tack the quadrant upon the edge of a small wooden block so that it will stand in a vertical plane; be sure the edge of the quadrant is parallel with the bottom of the block as in B. Cut a piece of tin of the shape and twice the size of A. Bend *a* over *b* and bend *c* over *b* to form a right angle. This piece of tin will serve as a rider to be moved up and down on the circumference of the quadrant. Stick a pin into the block at the center of curvature. A simple water level may be fixed to the block to aid in finding the horizon, as shown in the lower part of the figure. Take the altitude by setting the instrument on a horizontal support and sighting across the pin and rider; for the sun, make the shadow of the rider fall on the pin.

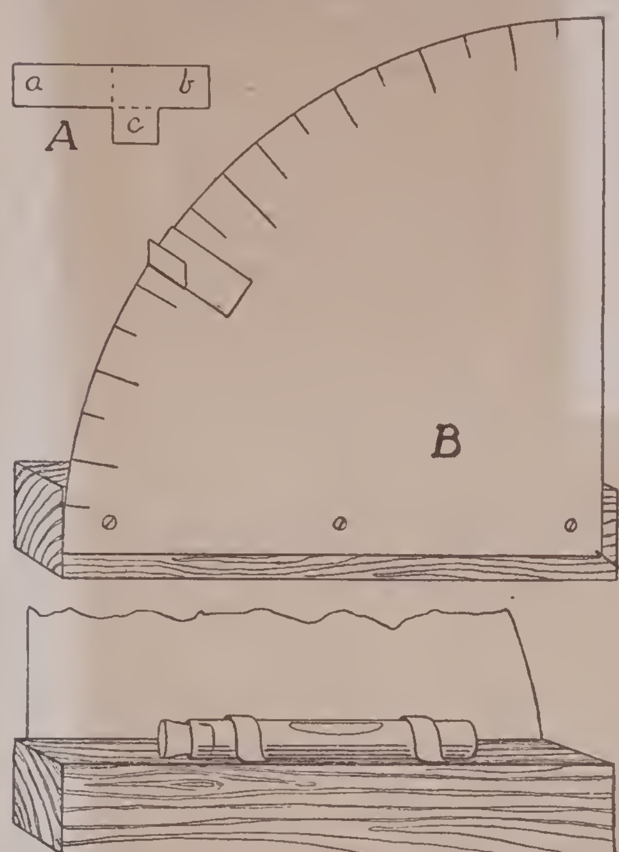


Fig. I.

A still simpler quadrant instrument may be made by each pupil on the cover of his note book or on a thin board. (Fig. II.) Draw a semicircle about a point *A* in the center of the edge of the cover. Point off every five degrees, beginning with 0 at the central point of the semi-circle. Fasten a pin in the point *A* and from it drop a small thread. On the end *B* fix a split shot, thus making a plumbline. By sighting along the edge of the cover, at the point to be measured, and holding the plumbline securely in the place it falls, the altitude of the point may be read. This instrument is especially adapted for measurement of altitudes in field work. Its disadvantage lies in the fact that the angle indicated is not identical with the angle measured. If this instrument is used the instructor should explain the equality of the two angles.

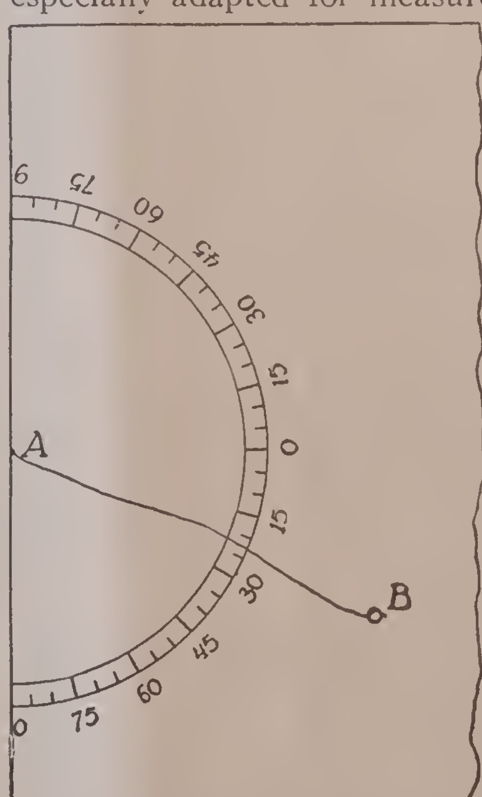


Fig. II.

The object of Exercise I. is to familiarize the pupils with the practical measurement and delineation of angles. It is a simple exercise with which to initiate a class into laboratory work.

Exercise VII. should be started immediately after Exercise I. is completed. This work is intended for out-of-school observation work. It extends over several months. The instructor will need to keep the subject in mind, provide facilities for the work, and question the pupils repeatedly about their progress. Under VII., 1, as in several other places, favorable times for observation should be designated by the instructor.

Demonstrations to precede Exercise II. (a) Use a globe to show the shape of the earth and the appearance of latitude and longitude lines when the globe is held in different positions. (b) To show oblateness of the sphere due to rotation use the rotary machine with the brass hoop attachment.

Exercise II. should be done by each pupil, though they may work in pairs. Each globe should be furnished with a tin or wire hoop, just large enough to allow the globe to turn within it. Pins may be used to mark this circle of illumination, but they injure the globe and consume much time. The axis of the globe should be set vertically during Exercise II.

Demonstration to follow Exercise III. Discuss Mercator's, conical, and other projections to familiarize the pupils with the appearances, sizes, etc., of land masses when represented by the different projections.

The horizon circle used in Exercise IV. may be easily manufactured by cutting a broad circle out of tin or stiff cardboard, having the diameter of its hole the same as that of the globe. Two pieces of heavy wire should be attached at their centers and bent down so as to hold the horizon disc just 90° from any place on the globe over which the intersection of the wires is placed. See Fig. III.

Demonstrations to take the place of, or to supplement Exercises IV. and V. To show that rotation produces the alternation of day and night: (a) Hold a globe in a beam of light, or with a tin ring separate the imagined light hemisphere from the dark one, having the axis at a right angle to the light rays. As the globe rotates watch a point 45° N. move through the light and the shadow. Incline the axis and have the pupils note the difference in the length of the day at the same point. By placing a ring 18° behind the circle of illumination, the reason for the difference in the length of twilight at different latitudes can be clearly demonstrated. (b) Pin to a globe, at your latitude, a pasteboard disc, about six inches in diameter. This will represent the horizon for an observer at the center of the disc. Draw an east and west line through the disc, using the pole as the center and the distance from the pole to the pin as the radius. Draw a north and south line along the meridian. Place the globe in the proper position to the sun, or to a bright light, to represent the time of the year considered. Starting with the horizon disc on the night side of the earth, rotate the globe eastward into the sunshine. The sun rises for the observer when the pin first casts a shadow on the disc. The direction of the shadow shows the place of sunrise. The shadow will shorten to noon, the amount of shortening depending upon the season, and will then lengthen and finally disappear in a direction opposite to the place of sunset. The amount of rotation required to pass the disc from its edgewise position to the sun at sunrise, to its edgewise position at sunset, shows the length of day for the season considered. In this same way the length of day, the place of sunrise and sunset, and the approximate height of the noonday sun, may be demonstrated for any place on the globe at any time of the year. From thus noticing the shifting of the pin's shadow across the disc, pupils may be led to see the principles involved in a sun dial and some in each division may be interested to make one which will keep time roughly from 9 a. m. to 3 p. m.

Fig. III.

In Exercise V. many pupils will find it too difficult a step to determine accurately, the altitude of the sun on March 21, June 21, etc., at the places given. It may need to be demonstrated for them that the horizon of any place is 90° from its zenith, and to find the altitude of the sun always subtract the latitude of the place from 90° and add the distance of the sun north or south of the equator when the sun is in the same hemisphere as the place, and subtract the distance of the sun north or south of the equator when it is in the opposite hemisphere.

The results of Exercise VI. should be compared with the correct length of a degree of longitude on the different parallels as given in the table below. Exercise VI. may be supplemented by a demonstration to show how the correct actual length may be determined mathematically. The length of a degree of longitude, on any parallel, may be computed by multiplying the length of a degree of longitude at the equator by the cosine of the given latitude. This cosine is the ratio between the radius of the parallel circle of the given latitude and the radius of the equator.

Table of Cosines and Lengths of Degrees of Longitude.

Latitude.	Natural Cosine of angle	Degree of Long. in miles
0	1 0000	69.172
10	.9848	68.129
20	.9397	65.026
30	.8660	59.956
40	.7660	53.063
50	.6428	44.552
60	.5000	34.674
70	.3420	23.729
80	.1736	12.051
90	.0000	00.000

Discuss the application of latitude and longitude lines in the survey of United States lands, sections, townships, ranges, principal meridians, correction lines, etc.

THE ATMOSPHERE.

Demonstrations for the first study of the atmosphere, showing the composition, uses, and properties of the atmosphere.

(*a*) To show the use of the air in combustion, exhaust the air from a jar in which a lighted candle has been placed.

(*b*) To show the relative power of different gases in supporting combustion, try to burn a splinter, a piece of sulphur, a watch spring or picture wire and a piece of magnesium ribbon, in jars of oxygen, nitrogen and carbon dioxide.

(*c*) To show the relative amount of oxygen in the air, burn the oxygen out of a jar which is turned over water.

(*d*) To show the presence of water vapor in the apparently dry atmosphere, fill a jar (a calorimeter with a polished surface is good) with ice water, and demonstrate the apparent "sweating." Call attention to the collection of water drops and frost on windows.

(*e*) To show the presence of dust in the atmosphere, darken the room to sunlight except by a narrow opening. To show the large amount which the air will hold, clean two dusty erasers near the beam of light.

LIGHT.

Demonstrations, to precede Exercise VIII., to show the composition of sunlight and refraction of light.

(*a*) Throw the solar spectrum upon the wall or a screen. Have the pupils find the primary colors. By diagrams show how the light is broken up by the prism, and the reason for the arrangement of colors.

(*b*) With a primary color disc, rotating on a rotary machine, blend the colors into grayish white. Such a disc can be made easily by painting narrow sectors on cardboard.

(*c*) Fill a battery jar with water. Place in it, at an angle, a straight rod, as a meter stick, and demonstrate the refraction caused by the difference in the density of air and water. This may be made still more apparent by floating an inch or two of oil on top of the water.

*"The colors of the sky and clouds should be recorded from direct observation by the pupils. . . . The value of sunset colors as weather indicators may thus be learned. In our winter climate of rapidly changing weather, a very clear sunset usually marks the middle of a fair-weather spell, soon to be followed by a change to cloudy weather. The colors in the sky opposite sunrise and sunset should also be noted. Very few persons seem to know that the dull blue sky under the rosy twilight arch opposite sunrise or sunset is the shadow of the earth."

* From *The Teacher's Guide,* by W. M. Davis, pp. 37-38.

Demonstrations to accompany this study.

(*a*) To show the nature of lightning. Produce a spark between the poles of an electric machine. Compare the knobs to cloud masses and the sound to thunder. Insert the edge of a piece of heavily glazed paper, which will cause the spark to run over the surface of the paper. Allow the spark to perforate softer paper. Show the attraction between pith balls and an electrified gutta-percha ruler or glass rod. Show the natural magnetic properties of a piece of magnetite. The isogonic map required for Exercise IX., 3, may have to be made by the instructor. A good map is to be found in the appendix of Tarr's *New Physical Geography.*

HEAT.

Parts of Exercise X. require gas or other means of heat in the laboratory, and may need to be omitted in many cases. These parts are therefore given here in a more complete form for *demonstrations.* They may be used to supplement the laboratory work and should then follow Exercise IX.

(*a*) To show the effect of heat on a solid. Provide a board about two feet long and four or six inches wide. (Fig. IV.) Take a brass rod about one-fourth inch in diameter and two feet long (a), and bend about six inches of one end to a right angle. Fasten the bent end firmly into the board, near one end, so that the long arm will be parallel with the board. Attach one end of a small brass wire, about three feet long, to the board underneath the free end of the rod, and solder or wire the two together, allowing the wire to extend above the rod. Another wire should extend up beside the first, but not touching the rod. Place the two wires in line and heat the horizontal rod by passing a flame along it. The effect of expansion wiil be shown by the end of the pointer moving away from the stationary wire. When the rod cools, the two wires will again coincide.

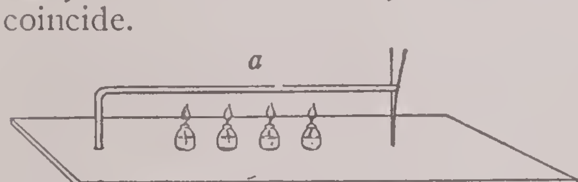


Fig. IV.

(*b*) To show the effect of heat on a liquid. Provide a small flask with a rubber stopper having two holes. Put a thermometer into one hole and a glass tube about two feet long into the other. Fill the flask with colored water so that when the stopper is pressed into place the water will stand in the tube two or three inches above the stopper. Heat the flask on a sand bath and note how many inches the water rises for every degree of increase in temperature.

(*c*) To show the effect of heat on a gas. Use a similar flask and tube as in (b), but without the hole in the stopper for a thermometer. Immerse the free end of the tube in water contained in a glass vessel. By holding the hands around the flask, bubbles of air will escape through the water. Raise the heat of the flask by friction rubbing and note the result. Heat the flask further with a flame and much more air will be driven out. When the flame is withdrawn water will be forced up the tube into the flask, taking the place of air driven out by expansion.

(*d*) The boiling point of water may be demonstrated as in Exercise X., 2, if it is impossible for the pupils to do it in the laboratory, but this exercise should be supplemented by the following demonstration to show the effect of decreased atmospheric pressure on the boiling point: Have a connection at hand that will fit tightly into the extra hole of the stopper and connect with the air pump or exhaust bulb. Boil the water in the flask and cool till all boiling stops and the thermometer shows decreased temperature. Exhaust the air in the flask until the boiling starts. Read the temperature. How does the decreased pressure affect the boiling point? Discuss the effects of high altitude on the boiling point and on cooking.

To make the helior to be used in Exercise XI. for determining the relative amounts of sunlight received on the earth's surface from the sun at different altitudes. Make a square tube having four square inches of inner measurement

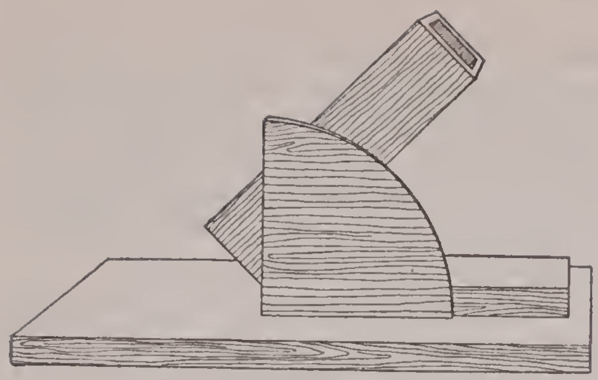


Fig. V.

at each end, and attach it with a hinge to the middle of a board of the same width and twice the length. Fasten to one edge of the board a wooden quadrant for reading the angle of elevation of the tube. See Fig. V. By adjusting a candle in front of the tube, measurement of the lighted surface may be made at any angle, or the space may be determined by sighting through the tube at a ruler which is laid on the base parallel with its edge.

The hourly temperature record required in Exercise XII. may be obtained from the nearest Weather Bureau Station. Care should be taken to get a record for days of normal temperature changes for this exercise.

The isothermal and range charts required in Exercise XIII. are found in all text books, but some of them are very indistinct. In such a case the instructor should make large wall charts showing the required data. The value of this Exercise is not to be found in the copying, but in the preparation for the Exercises further along.

The table in Exercise XIV., containing the weather map data, is taken from Dryer's *Lessons in Physical Geography,* page 411, and makes a good map. For more data see Ward's *Exercises in Meteorology.* The instructor should make a map and read the data from the map in order, or should instruct the class to begin at one corner of the map and look up the data required for each place named on the map in the alphabetical list given. Otherwise a great loss of time will occur by attempting to look up the places as they occur in the table.

Exercise XV. should be followed by several demonstrations to show the effects of atmospheric pressure in pumps, syringes, etc., to enforce the realization that the water is not sucked up but pressed up.

Demonstrations to follow Exercise XV. (a) To show the principle of a mercurial barometer. Fill a Torticelli tube with mercury. Place the finger over the open end and invert the tube in an evaporating dish half filled with mercury. By pressing upon the surface of the mercury in the bath the pressure causing high barometer may be demonstrated.

(*b*) To show that air has weight. Solder a bicycle valve into a one or two quart air-tight tin can. An ether can is best. Weigh the can; pump air into it and weigh again.

(*c*) To show the pressure of the atmosphere. Exhaust the air from under a bell jar, try to remove it from the base.

(*d*) Fit a large tin can, such as an old syrup can, with a tight cork. Put in enough water to cover the bottom to the depth of about an inch. Heat till steam is escaping rapidly. Remove the flame and quickly stopper the can tightly. As it cools the air pressure will cause a collapse of the can. The cooling may be hastened by flowing cold water over the can.

If the class has not kept the barometric readings previously the instructor will need to furnish the barometric data for Exercise XVI. This may be obtained from the nearest Weather Bureau station. It may be best procured from a series of weather maps, and in this case the accompanying weather data should be given to the class.

Demonstration to precede Exercise XIX., to show the convection currents in liquids. Construct a convection tube (Fig. VI) by bending a glass tube three feet in length into a square. Fill with water which contains some floating particles, like the dried residue of an ink-well, and connect the ends of the tube with a piece of rubber tubing. Heat one corner of the tube to produce the current. It may be worth while to boil water in a large beaker or broad shallow pan with a flame under its center to show the formation of currents throughout less circumscribed areas that the application of the principle may be more easily made to wind currents.

The following *demonstration* may be substituted for Exercise XIX., 1, if desired. Make an inch hole in a stiff cardboard or a board, and four or five inches from it, around a circle as large as a candle, make several small holes. Put the cardboard over a large battery jar and place Argand chimneys over the openings (Fig. VII). Place a lighted candle within the circle of holes, and by holding a piece of smoking waste or cotton cloth over the other chimney the direction of the air current may be readily demonstrated. If the cotton has been soaked in a saturate solution of saltpeter and dried a good volume of smoke will be made.

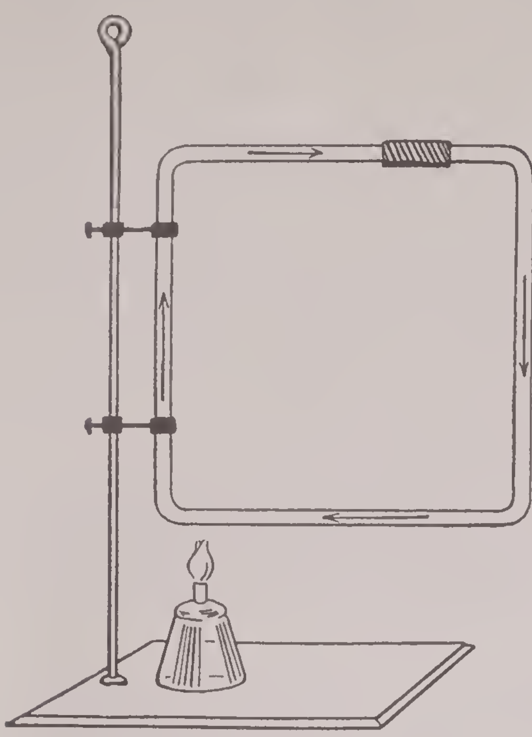


Fig. VI.

To show the application of this principle to ventilation. To show how two small openings are better than one larger one. Place an Argand chimney over a piece of burning candle and it soon goes out. If the chimney be divided lengthwise into two compartments by a strip of tin which reaches down nearly to the flame, the candle will continue to burn. Smoking waste will show the circulation.

Ask the pupil to make a diagram and explain the circulation of the hot water from the tank attached to the kitchen range; also to describe the movements of air near the parlor lamp. (The movement can be detected by the flame of a lighted match held close to the lamp.)

If the preceding Exercises have been done comprehendingly the pupils should be able to determine the equatorial air currents as called for in Exercise XX. It may be necessary to review the causal conditions in a class quiz before attempting Exercise XX. The Pilot charts for Exercise XX., 2, for both the Atlantic and the Pacific oceans, may be procured from the United States Hydrographic office, Washington, D. C. A statement should accompany the request, stating what use is to be made of the charts. Old charts will do as well as the more recent ones.

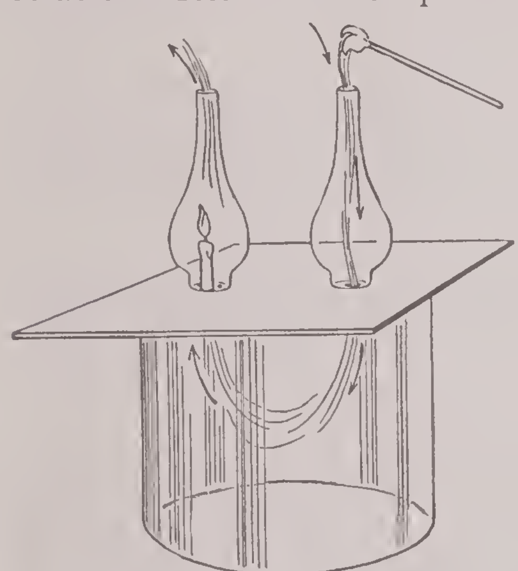


Fig. VII.

Demonstrations to follow Exercise XX., showing the causes for the deflection of the planetary winds. Any one of the following may be used, but often it is the case that one demonstration will appeal to some of the class and another will be needed for the others.

(*a*) On a globe show that the air currents moving toward the equator are going into latitudes in which the degrees are longer, consequently the currents are going from more slowly moving to more rapidly moving areas, and the winds would be deflected to the west. This is easily shown by rotating the globe with one hand while with the other a piece of chalk is drawn rapidly from a point on the globe about 30° N. directly toward a point in the floor opposite the South Pole. The same thing may be shown for the poleward currents.

(*b*) Ferrell's Law may be nicely illustrated as follows:

Bodies of air, and all other bodies, in motion continue to move in the same direction unless turned from their course. On a globe set a pointer, representing a moving mass of air, at 60° north latitude, pointing north (globe direction); observe the exact place in the room at which the pointer aims. Rotate the globe slowly through 30 or 40 degrees, keeping the pointer aimed at the same place. Now is it pointing to the right or to the left of north? Bring the globe back to the first position and set the pointer east. Observe the place at which the pointer aims. Rotate as before, keeping the pointer aimed at the same

place. Does the pointer now point to the right or to the left of east? Repeat the same process for south and west. Does the rotation of the earth cause winds blowing in any direction at latitude 60° north to deflect to the right or to the left? Repeat the study at latitude 10 degrees north, at the equator, and in the Southern Hemisphere. State the facts observed in the demonstration as Ferrell's Law.

(*c*) By means of the rotating table:

Construction. (Fig. VIII.) Insert a cylindrical wooden axis two or three inches in diameter, by square dovetailing, into a round table top three feet across. For support join the four legs diagonally by cross-pieces at the top and near their centers. Insert the axis through a hole in the top cross-pieces, and lower it to rest on the bottom cross-pieces by a pivot projection fitting into a hole. The table is to be turned by a pupil pulling a string fastened to and wound around the axis. Use graphite to prevent squeaking. Near the edge of the table top fasten by hinges a small wooden trough, four or five inches long, aimed at the center of the table.

Let the table represent the Northern Hemisphere, with the edge as the Equator and the center as North Pole. On the stationary table a ball, such as used in ball-bearings, dropped into the slanting trough will go across the center of the table; when the table is turned anti-clockwise the ball curves to the right before reaching the center. If the ball is rolled outward from the center of the table, from a pasteboard trough held in the hand, it curves to the right before reaching the edge.

In a similar way demonstrate that in the Southern Hemisphere moving objects are deflected to the left, by considering the center of the table the South Pole and turning it clockwise. The amount of deflection may be varied by changing the speed of rotation or the slope of the hinged trough.

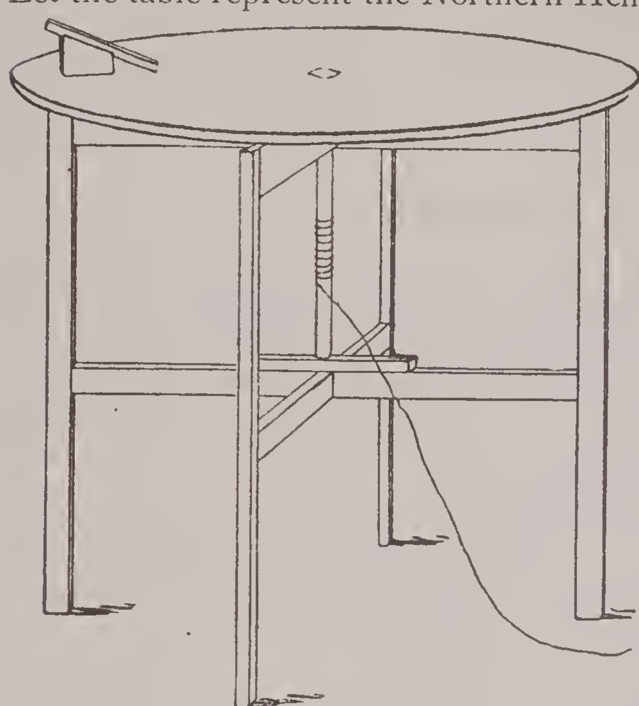


Fig. VIII.

ATMOSPHERIC MOISTURE.

The object of Exercise XXIII. is to make the pupils realize the meaning of relative and absolute humidity and to show the principle involved. It may be done by the instructor as a class demonstration. The hygometers for use in Exercise XXIV. may be furnished the pupils ready made and then part I. may be omitted. Very immature pupils will find no difficulty in doing this Exercise if properly directed, but the resulting value may not pay for the time consumed.

Demonstrations to precede Exercise XXV.

(*a*) To produce a miniature rain storm.

Take a quart jar made of clear glass. Fill it one-third full of alcohol. In a shallow water bath heat it to the boiling point. Remove it from the fire and cover the mouth of the jar loosely with a porcelain evaporating dish or an aluminium cup filled with ice water. After a few minutes a fine mist-like precipitation may be seen going on in the jar. If the experiment be carefully made a cloud may be distinctly seen next to the condenser.

(*b*) To show the formation of fog in air containing dust.

A large acid bottle is provided with a two-hole rubber stopper. Through one hole is a tube leading to a force pump, bicycle pump or atomizer bulb. A little water is put into the bottle to furnish moisture. Place the thumb over the other hole in the stopper and pump some air into the bottle. Remove the thumb and only a slight fog will be seen. Drop a burning match into the bottle to furnish "dust" and repeat the operation. A dense fog will form.

Ask the pupils to make observations and reports on the formation of dew and

frost on the grass, on objects lying on the ground, on objects under a tree or shed, on wood and stone sidewalks.

At a convenient time at about this point of the work pupils should be induced to visit a Weather Bureau station and inspect the apparatus in order to come to some realization of the principles involved in the work. Few people appreciate the real importance of observations and warnings.

The value of Exercise XXV., 2, is in the association of the rainfall areas with the topography. It will be necessary to have a quiz on this work to develop it as it should be. The instructor should have saved all weather maps and bound them together in some manner, consecutively by weeks or months. If this has not been done it is always possible to get the officers at the stations to save enough maps for each day for a week to supply the class with the consecutively arranged series required in Exercise XXVI. As soon as the number of maps will allow of a choice only the normal maps should be given to the pupils for this work.

For Exercise XXVII. the weather maps should be cut in two just below the map. For convenience the instructor should number the upper and lower portions of each map correspondingly. Then after this exercise is completed the lower portions of the maps may be given to the pupils having the respective upper portion and a comparison may be made of their work with the official report.

THE EARTH'S SURFACE.

Exercise XXIX. is really a review of all the causal meteorological conditions, showing their result in the continental rainfalls. The topographical causes in the different areas should receive especial attention in a quiz preceding the Exercise XXX. It may be best to do the work outlined in Exercise XXX. in a class recitation by means of the map given. This exercise is the most important in the physical geography work as bringing out clearly the specific causal relation between the earth regions and their inhabitants.

Exercise XXXI calls for data which the instructor may have to furnish if it is not given specifically in the text used. It may be found in Dryer's *Lessons in Physical Geography*, page 39, in the best form. The object of this experiment is to make real the differences existing in the distribution of land and water.

MINERALS, ROCKS AND SOILS.

It is easy to overdo this portion of the work. Its intent should be to simply familiarize the pupils with enough of the materials common to their environment to have them realize the relations of origin existing between the classes. This will need to be developed in class work to show the rotation of materials through the igneous, fragmentary, sedimentary and metamorphic stages. The following books will be found helpful for reference:

Stories of Rocks and Minerals. Fairbanks. Educational Publishing Co.
Practical Study of Common Minerals. Roy Hopping, publisher, No. 129 Fourth Avenue, New York.
Common Minerals and Rocks. Crosby. D. C. Heath & Co.
Manual of Mineralogy and Lithology. Dana. Wiley & Sons.
Stones for Building and Decoration. Merrill. Wiley & Sons.
Rock, Rock Weathering and Soils. Merrill. Macmillan Company.
Reports of Division of Soils. Department of Agriculture, Washington, D. C.
Report on Building Stones. Tenth Census.

The most convenient form for handling the specimens required in this work is to fit out small boxes (cigar boxes deodorized by a drop of oil of wintergreen), each with a steel knitting needle, a piece of glass, a small vial of hydrochloric acid and a short glass dropping rod, a rag and a simple magnifier. There should be a box for each pupil. There should be enough sets of labeled specimens of each class to furnish each box so that all pupils will be working on the same class of materials at the same time. The unlabeled specimens should not be simply the left overs, but should be as carefully selected as the specimens for initial study. Exercises XXXV., 2 and 3, may be done as demonstrations before the class. In this event the percolators should be made of large tubing so that results will be easily seen by the class. In case the soil is so fine as to go

through the percolator a piece of cheese cloth or filter paper should be laid over the stopper, within the tube. It would be best to furnish the percolators to the class ready made.

Demonstrations to follow Exercise XXXV.

(*a*) To show the principles of stratification.

Fill a large glass jar about two-thirds full of water. Add a quart or two of a mixture consisting of pebbles, sand and fine clay. Stir vigorously, then gradually decrease the speed, thus allowing the sediment to settle.

(*b*) To show rock-folding.

Procure a rubber band or sheet, several inches wide and a foot and a half or two feet long. (A piece of bicycle inner tube will do.) Arrange it so that it can be stretched and released slowly and uniformly. This may be done by fastening each end between two wooden blocks. These should be long enough to project an inch or two on each side, and securing each end of the blocks by a string to a hook or nail in the top of the table. Stretch the band, secure it in this position, and spread on it a sheet of some soft, plastic material like damp clay or putty. Being sure to spread under the first layer a sheet of paper to allow the rubber to slip under it easily. Several thin layers of different colored materials, such as damp sands and humus, may be put on. The outer edge should be trimmed evenly to show the "strata." Release the band at one end and let it shrink slowly to its normal size. The layers on top will fold like mountain ranges. See Annual Report U. S. G. S., Vol. XIII.: the Mechanics of Appalachian Structure.

(*c*) To show the formation of stalactites and stalagmites.

Bore several small holes through the bottom of a tight box, a chalk box will do. Mix plaster of Paris with one-third sand. Make a solution and fill the box around all edges and for a couple of inches over the bottom. Suspend the box about six inches above a dressed board. The whole apparatus should be placed over a sink. Keep the box filled with lime water or a solution of alum. If the apparatus is properly adjusted the drops of water will evaporate, some before and some after falling, forming stalactites and stalagmites. It should be in operation for some weeks before it is to be shown in the demonstration.

TOPOGRAPHIC STUDY.

The following *demonstration* may be substituted for Exercise XXXVI. if desired: A model of an irregular mountain or island can be easily made of stiff cardboard by sewing the cardboard into the desired shape and tacking it onto a platform of thin boards. The cardboard should be covered by pasting over it a layer of black pattern paper, such as can be obtained at any tailor shop. It would be well to make one whose contour lines would be like those in the cut of Exercise XXXVII. Draw on its surface several contour lines. Hold the model so that the pupils can see it from a horizontal viewpoint—the contour lines appear straight and parallel. Tip it so that the pupils see it vertically—the contour lines appear as they would on a map. Ask the pupils such questions as: How is a steep slope indicated by contour lines? How a gentle slope? How a uniform slope? How a hill or mountain side? How a ravine? Ask the pupils to make models at home, as complex as possible, with contour lines drawn; display in class This demonstration should be followed by Exercise XXXVII. If a task could be set for the pupils to do individually of mapping some small portion of the surrounding region much practical good may be derived.

Exercise XXXVIII. may be given as a demonstration if the laboratory facilities will not permit of the individual work. The sand to be used in all modeling work should be the Albany moulding sand and may be procured at any foundry. The topographic sheets which are presented for laboratory work have been selected with care both as to type of land form and ease of interpretation. More work is given on some sheets than on others, so the same amount of time cannot be devoted to each. Some of the studies can be completed in one hour, while others will need two or more hours. It is not necessary that all of the maps here given should form exercises for laboratory work. A choice may be made by the instructor of some which may be handled in a quiz. The laboratory work on each sheet should be preceded by a lecture-recitation dealing with the region

in a broad way and bringing out the geologic structure and the physiographic processes which have produced the present topography. Use should be made of a large United States map, the map of aggregated sheets of the region, and geologic and topographic sections drawn on the blackboard or on the black pattern paper mentioned above. This paper forms a very convenient base upon which to make drawings and maps which the instructor desires to preserve. Common crayon may be used and fixed in place with an atomized spray of shellac dissolved in wood alcohol.

All of the following map sheets except the Mississippi River Sheet No. 14, may be procured from the United States Geological Survey, Department of the Interior. Every instructor should send to Charles D. Walcott, Director, for a complete list of the publications and maps of the United States Geological Survey. Nowhere can more valuable material be found than in the monographs, folios and bulletins of this department. The Sheet No. 14 of the lower Mississippi River may be procured from the Mississippi River Commission, 1115 Fullerton Bldg., St. Louis, Mo.

The following order of map studies is recommended:

(*1*) River Development:
(*a*) Ottawa, Ill.—Youthful stage.
(*b*) Charleston, W. Va.—Mature stage.
(*c*) Caldwell, Kan.—Old age stage.
(*2*) Mississippi River:
(*a*) Savanna, Ill.—Upper Valley.
(*b*) Donaldsonville, La.—Lower Valley.
(*c*) Sheet No. 14 of the lower Mississippi River.—Meanders.
(*3*) Glacial Phenomena:
(*a*) Whitewater, Wis.—Drumlins, Terminal Moraines.
(*b*) St. Paul, Minn.—Drift, Moraine, Drainage.
(*4*) Sea Shores:
(*a*) Atlantic City, N. J.—Barrier Beach.
(*b*) Boothbay, Me.—A Fiord Coast.
(*5*) Plains, Plateaus and Mountains:
(*a*) Wicomico, Md.—A Coastal Plain.
(*b*) Kaibab, Ariz.—A Plateau.
(*c*) Harrisburg, Pa.—Appalachian Ridges.
(*d*) Anthracite, Colo.—Rocky Mountains.
(*e*) Mt. Shasta (special), Cal.—A Volcano.

Suggestions for mounting topographic sheets.

The single sheets for laboratory study may be used without mounting, but to preserve them for any length of time they should be backed with cloth or cardboard. Cardboard mounting can be done quickly and the sheets will last several years. Trim the sheet to a little smaller than 14 by 20 inches and fasten to 12 or 16 ply cardboard 14 by 20 inches by putting a little paste on the corners, the middle of the edges and the center of the sheet, which will be sufficient to hold it.

The following method is suggested for mounting aggregated sheets:

Lay the sheets on the floor or table in proper order. Fill in vacant places with blank paper. Trim the margin of the bottom and right sides of the upper left-hand sheet to within three-fourths inch of the map. The sheet next on the right should be trimmed close to the map at the left side, and at the bottom and right sides the same as the first sheet, and so on to the last in that row, which should not be trimmed on the right side. The first to the left in the second row should be trimmed close on top and right sides and within three-fourths inch on the bottom, the next sheet trimmed close on the top and right sides and to within three-fourths inch on the other two sides, and so on to the last sheet in that row, which should not be trimmed on the right side. Trim the sheets in the succeeding rows in like manner until the bottom row is reached, which should match the row above it and have full margin on the left, bottom and right sides. Paste the sheets of each row together, using a warm flatiron to smooth out the wrinkles if necessary. Match the contours, streams, etc., as accurately as possible. Then paste the rows together. The top and bottom should be reinforced with strips

of heavy paper and the sides with strips of wide tape pasted over the edges. Light strips of wood may be tacked to top and bottom to hold the map up, but spring rollers are much better. If a stronger map is desired, paste the sheets on cheese-cloth or muslin. Spread the cloth on a table or on the floor, free from large cracks, and cover it with a good coat of flour paste. If the map is to be wider than the cloth, lap another piece of cloth on the first; the paste will hold them together. Trim the topographic sheets and arrange them in order. Cover the back of each with paste a few minutes before you lay it in its place on the pasted cloth. Rub the sheet down smooth in place with a towel. When the whole map is pasted the cloth may be turned over the margin of the paper, thus binding it firmly.

A very convenient arrangement for hanging these topographic maps is by means of the Dennison Cloth Suspension Rings, which may be procured at any stationer's. These should be stuck on the upper margins of the maps at some standard distance apart (two feet or a multiple of two is a convenient distance), so that all maps will hang on the wall hooks in the laboratory which adhere to the same standard.

The following is the list of aggregate sheets, in their order for mounting, which will be useful in the study of each respective sheet. A dash shows that no map has as yet been published. The names in italics are of the sheets designed for special study:

OTTAWA, ILL.

Hennepin, La Salle, *Ottawa,* Marseilles, Morris.

CHARLESTON, W. VA.

Kenova, Huntington, *Charleston,* Kanawha Falls.
Prestonsburg, Warfield, Oceana, Raleigh.

CALDWELL, KAN.

Great Bend, Lyons, Hutchinson, Newton.
Pratt, Kingman, Cheney, Wichita.
Medicine Lodge, Anthony, *Caldwell,* Wellington.

SAVANNA, ILL.

———, *Savanna.*
Goose Lake, Clinton.
Le Claire, ———.

DONALDSONVILLE, LA.

Donaldsonville, Mt. Airy, Bonne Carre, Spanish Fort.
Thibordeaux, Lac des Allemands, Hahnville, New Orleans.

WHITEWATER, WIS.

Madison, Sun Prairie, Waterloo, Watertown, Oconomowoc, Waukesha, Milwaukee.
Evansville, Stoughton, Koshkonong, *Whitewater*, Eagle, Muskego, Big View.
Brodhead, Janesville, Shopiere, Delevan, Geneva, Silver Lake, Racine.

ST. PAUL, MINN.

Anaka, White Bear.
Minneapolis, *St. Paul.*

ATLANTIC CITY, N. J.

Mullica, Little Egg Harbor, Long Beach.
Great Egg Harbor, *Atlantic City,* ———.
Sea Isle, ———, ———.

BOOTHBAY, MAINE.

———, ———, Gardiner, Wiscasset.
Gray, Freeport, Bath, *Boothbay.*
Portland, Casco Bay, Small Point.

WICOMICO, MD.-VA.

Brandywine, Prince Frederick, Sharps Island.
Wicomico, Leonardtown, Drum Point.
Montrose, Piney Point, Pt. Lookout.

KAIBAB, ARIZ.

St. Thomas, Trumbull, *Kaibab,* Echo Cliffs.
Camp Mohave, Diamond Creek, Chino, San Francisco Mountains.

HARRISBURG, PA.

Sunbury, Shamokin, Catawissa, Mahanoy.
Millersburg, Lykens, Pine Grove, Pottsville.
Harrisburg, Hummelstown, Lebanon, Wernersville.

ANTHRACITE, COLO.

———, Aspen.
Anthracite, Crested Butte.

SHASTA (SPECIAL), CAL.

Shasta (Regular), Modoc Lava Bed, Alturas.
Red Bluff, Lassen Peak, Honey Lake.

SUGGESTIONS ON THE USE OF THE TOPOGRAPHIC SHEETS.

The Ottawa Sheet is selected to show the work of young streams on a nearly level plain. Beginning at the bluffs along the Illinois River, the streams gradually work backward, and, under the influence of a rather steep slope, cut narrow, deep valleys into the upland. Information bearing on this region may be found in Monograph No. 38, U. S. G. S., and *Geography of Chicago and Its Environs,* published by the Geographic Society of Chicago. Rand, McNally & Co.

The Charleston Sheet shows streams in all the earlier stages of development and a thoroughly dissected plateau. Description of this region is found in Physiographic Types No. 1 and in the Charleston Folio No. 72.

The Caldwell Sheet shows streams well advanced in development and largely controlling the topography of the region. The area is well described in Physiographic Types No. 1 and in the State Geological Survey of Kansas.

The Savanna Sheet is typical of the Upper Mississippi River Valley. This region is described in the Sixth Annual Report U. S. G. S. under the *Driftless Area,* in the Eleventh Annual Report U. S. G. S. under *Pleistocene History of Northwestern Iowa;* and in Monograph of U. S. G. S. No. 38.

The Donaldsonville Sheet shows a swamp flood plain with natural levees bordering the river. This is characteristic of the Lower Mississippi River Valley. The region is described in Physiographic Types No. 1.

In connection with the study of the Mississippi River Sheet No. 14, detailed maps of the river may be obtained from the Secretary of the Mississippi River Commission, St. Louis, Mo., especially those of the Upper and the Lower Valleys, which can be obtained free of cost for school use. The sheets of each should be pasted together and mounted. Additional information on the Physiography and Geology of the river may be found in Russell, Dana, Le Conte, Scott, Brigham, Mill's International Geography and any standard geology.

The Whitewater and St. Paul Sheets show glacial phenomena, such as kettle terminal moraines, ground moraines, drumlins and post-glacial drainage. Information on these regions may be found in the Geological Surveys of Wisconsin and Minnesota; Third and Seventh Annual Reports of U. S. G. S.; Monograph U. S. G. S. No. 25; Wright's *Ice Age of North America; American Geologist,* Vols. X. and XV. *Geography Around Devil's Lake;* and *Physiography of Southern Wisconsin.* The last two are published by the Wisconsin Geological Survey, Madison Wis. In connection with the study of this sheet (Exercise XLV) a special study upon the Falls of St. Anthony may be made. One student can look up the history of the Falls as a special topic. He should find out where the Falls began, why it began and that it is now stationary, being prevented by artificial means from cutting back further.

The Atlantic City Sheet shows a typical eastern United States coast south of New York. In addition to Physiographic Types No. 1, see the Sixth and Thirteenth Annual Reports U. S. G. S. and State Survey. Get United States Coast Survey Chart No. 122 (50 cents). From it copy on the sheets given the pupils the depths in Great Bay and along one or two lines running east from

the coast. Be particular to give all the depths in and near the channel leading to Great Bay and along the profile line east from Leed's Point.

The Boothbay Sheet shows a typical portion of the rugged New England coast. In addition to Physiographic Types No. 1, see *Geology of Mt. Desert* in Eighth Annual Report U. S. G. S., and *National Geographic Monographs,* published by American Book Company. Get United States Coast Chart No. 314 (25 cents). From it copy on the sheets given the pupils the depth of water in several bays. Draw a line, one-half inch from the bottom of the map, from Damiscove Island to the mainland and write the depths along it.

The Wicomico Sheet represents a typical portion of the geologically recent coastal plain where the streams are working in soil formations. The Nomini Folio No. 23 contains considerable information about this region, and the Seventh Annual Report U. S. G. S. also contains a paper on the region around the head of Chesapeake Bay.

The Kaibab Sheet represents one of the deepest parts of the Grand Canyon. Much has been written about the Canyon. See Monograph of the U. S. G. S. No. 2; Second Annual Report of the U. S. G. S.; *Exploration of the Colorado River,* by Major J. W. Powell; *In and Around the Grand Canyon,* by G. W. James, published by Little, Brown & Co., Boston. (At the end of this last publication is a bibliography of the Grand Canyon region.)

The Harrisburg Sheet is typical of the Northern Appalachians. See Physiographic Types No. 2, *National Geographic Monographs,* American Book Co.; and Thirteenth Annual Report of U. S. G. S.

The Anthracite Sheet represents a region in the high Rocky Mountains. The Anthracite-Crested Butte Folio No. 9 gives a good description of this region. (The folio is out of stock at present, but can be found in most public libraries.)

The Shasta (special) Sheet represents a young volcano. It is described in Physiographic Types No. 1.

In connection with the study of each topographic sheet the exercise requires the pupil to show some reproduction of the characteristics of the sheet, either by profile drawing or by sand modeling. It is hardly necessary to do each of these and instructors will need to instruct the class as to their choice.

The instructor may find it desirable to have pupils make longitudinal profiles of a few rivers. If Gannett's pamphlet on *Profiles of Rivers in the United States* is not available, the data given below may be found convenient. Any scale may be used, but probably the most convenient one is horizontal scale one cm. equals 100 miles, and vertical scale one cm. equals 1,000 feet. Where rivers have very steep slopes the vertical scale may be reduced to one cm. equals 2,000 feet. The first scale gives a vertical exaggeration of 528 and the second an exaggeration of 264.

I. MISSISSIPPI RIVER.

Stations.	*Distance From Mouth.*	*Alt. Above Sea Level.*
Mouth	0 miles	0 feet.
Ohio River	1097 miles	270 feet.
Minn. River	1943 miles	688 feet.
Minneapolis	1952 miles	794 feet.
Lake Itasca	2296 miles	1462 feet.

II. MISSOURI RIVER.

Mouth	0 miles	395 feet.
Ft. Benton	2074 miles	2565 feet.
Great Falls	2111 miles	3295 feet.
Three Forks	2340 miles	4000 feet.

III. OHIO—ALLEGHENY RIVER.

Mouth	0 miles	274 feet.
Pittsburg	963 miles	702 feet.
Red Bank River	1027 miles	821 feet.
Source	1300 miles	1700 feet.

IV. DELAWARE RIVER.

Mouth	0 miles	0 feet.
Belvidere	68 miles	235 feet.
Water Gap	81 miles	301 feet.
Port Jervis	127 miles	450 feet.
Deposit	212 miles	984 feet.
Source	280 miles	1886 feet.

V. HUDSON RIVER.

Mouth	0 miles	0 feet.
Troy	150 miles	5 feet.
Ft. Edward R. R. Bridge	190 miles	118 feet.
Secondaga River	216 miles	536 feet.
Schroon River	228 miles.	594 feet.
North Creek	248 miles	981 feet.
Tear of Clouds	300 miles	4322 feet.

VI. COLORADO—GREEN RIVER.

Mouth	0 miles	0 feet.
Grand Wash.	600 miles	1000 feet.
Naoaho Creek	905 miles	3220 feet.
	1435 miles	4750 feet.
Big Sandy River	1652 miles	6240 feet.
Source	1800 miles	7808 feet.

VII. COLUMBIA—SNAKE RIVER.

Mouth	0 miles	0 feet.
Snake River	312 miles	145 feet.
Weiser	618 miles	2123 feet.
Glenn's Ferry	792 miles	2500 feet.
	914 miles	4190 feet.
Salt River	1110 miles	5363 feet.
Shoshone Lake	1251 miles	7746 feet.

VIII. ARKANSAS RIVER.

Mouth	0 miles	117 feet.
Wichita	832 miles	1222 feet.
Pueblo	1334 miles	4700 feet.
So. Ark. River	1428 miles	6500 feet.
Tennessee Pass	1497 miles	10400 feet.

IX. PLATTE AND SO. PLATTE RIVERS.

Mouth	0 miles	940 feet.
Platte Canyon	623 miles	5492 feet.
Source	742 miles	10000 feet.

In connection with each of these characteristic regions some portion of the immediate locality which presents some of the characteristics under discussion, should be visited by the class. An outline for field study should be prepared by the instructor for the trip. The work would be of special value in connection with the exercises on river development, glacial topography and on shore lines. It would be most instructive if the pupils could make their own collections for pebbles for study in Exercise XLVI.

A Laboratory Manual in Physical Geography

By

Frank W. Darling
Head of the Department of Geography and Vice-Principal of the Chicago Normal School

Atkinson, Mentzer & Grover
Chicago Publishers Boston

THE PREFACE.

THE best friends of Physical Geography have been fearful of the introduction of laboratory work as a prominent part of the study of the science. And well they might be judging from some tendencies shown by the laboratory work in other sciences. A summarizing of the most objectionable inconsistencies which are found to be invading the laboratory work in Physical Geography may be helpful:

1.—Laboratory work should not be expected to take the place of real experiences out of doors, but to stimulate such observation and to supplement it. Any Physical Geography laboratory manual can do little more than suggest opportunities for excursions and individual out-of-door work, on account of the varying local conditions.

2.—Mere copying of maps, charts, diagrams, etc., is of little or no value. Such work must have in it something to stimulate the self-activity of the pupil, so that his work will give him a better realization of the principles involved. The final result may not show as perfect a map as if the work had been copied, but the aim of the teacher should be to teach the child rather than to secure an accurate map. On the other hand, the author believes that if the pupil is led to tabulate observed or collected data in diagrammatic form it will tend to bring the pupil to a better realization of the facts, and when followed up by intelligent questions that it will lead to a further understanding of the effects and relations.

3.—Another and probably the most dangerous tendency of Physical Geography laboratory work, at the present time, is the disposition to take up the time and attention with all kinds of pyrotechnics and monstrosities, to furnish a scientific wonderland instead of bringing the pupils to a comprehension of the simple underlying principles, the application of which has to do with relations existing between the earth and man. We continually presume upon the child's experience by assuming that he is familiar with these principles whose effects immediately surround him, when in fact, anything more than the simple observation of the fact itself has escaped them.

The author has attempted to avoid these errors by continually keeping in mind that *the aim and method of Geography study should be to familiarize the pupil with those natural causes and effects which the individual may observe in his immediate surroundings, to seek out the principle underlying the observed phenomena, and then to see the application of this principle as an interpreter of the more universal relations existing between earth and man.*

At the present time it is impossible to approach any standard series of exercises. In this Manual all parts of the subject are treated fully and probably twice as many exercises are given as can be attempted in one year's work with any first year High School class. It is intended that each instructor shall select the exercises which best fit the conditions in which his classes are placed. Enough instructive and simple exercises may be selected from each division of the subject to occupy a class which is poorly prepared and is working under the disadvantage of no equipment.

The credit for this Manual belongs to no one individual, but in the main to Ralph E. Blount, Jane Perry Cook, Kenneth C. Fitch and Calvin L. Walton, Instructors of Physical Geography in Chicago High Schools. In 1903 these experienced teachers, together with the author of this edition, prepared *A Laboratory Manual for Physical Geography* for use in the Chicago High Schools. The suggestions and criticisms of instructors who used the Manual for a year in Chicago and other cities have been made use of in preparing this edition of the Manual, which is in fact a revised and supplemented edition of the work into which the above named individuals put so much time and experience.

Acknowledgment should also be made to W. H. Snyder, Head of the Department of Geography in Worcester, Mass., Academy, and to Miss Mary McNair, Instructor in Physical Geography in the Hinsdale, Ill., High School, for valuable suggestions on the manuscript and proof. The relief maps accompanying the manual were made by Mr. G. Thorne-Thomsen, of the School of Education, University of Chicago, by the chalk modeling process, and their correctness and general quality will almost mark a new era in such productions.

FRANK WOOLSON DARLING.

CHICAGO, February, 1905.

Name——————————————

Address——————————————

Exercise I.

THE CONSTRUCTION AND MEASUREMENT OF ANGLES.

Material. Pencil, compasses, foot-rule, quadrant instrument.

(*1*) To construct an angle.

Draw two circles having the same center, one six inches in diameter, the other four inches in diameter. How many degrees in each circumference? What numbers will evenly divide 360? Why is 360 a convenient number to designate the number of degrees in a circumference? Draw two diameters at right angles to each other, dividing the circles into four equal parts or quadrants. How many degrees in a quadrant? How many degrees in a right angle? Mark off from the end of one diameter an arc of 30 degrees and draw its angle at the center. Mark off, in this same quadrant and also in another quadrant, arcs of 23½ degrees and draw their angles.

(*2*) To measure angular altitude.

With a quadrant instrument measure the angular distance between a horizontal line and a line from your eye to the corner of the ceiling. This angle measures the altitude of the ceiling corner above your eye. Draw this angle of altitude and write in it the number of degrees it represents. Repeat with several objects in the room and with a tower or other high object outside.

(*3*) To find the altitude of the sun.

With the quadrant instrument, find the altitude of the sun. Draw the angle of altitude and indicate the number of degrees.

Name——————————————————

Address——————————————————

Exercise II.

ROTATION AND ITS EFFECTS.

Material. A six-inch globe, a hoop to fit about the globe, outline map of the United States, outline map of the world.

(*1*) To determine the points and circles on the globe caused by rotation.
Place the globe on the desk so that the axis is vertical. Rotate the globe slowly. What two points have the least movement? At what place on the globe does a point have the greatest speed? What line is determined by the rotation of this fastest moving point? How many degrees are there between the slowest and the fastest moving points? How will the circles drawn by any moving points on the globe lie in relation to the equator? Why are these circles called "parallels of latitude"? How many parallels might be drawn?

(*2*) To determine the amount of the earth's surface illuminated at one time.
Place the globe in a strong light. How much of the globe can be illuminated at one time? How much of the globe can you see at one time when the equator is on a parallel with the eye and some distance from it? Place a hoop about the globe to separate the part illuminated or visible from that part which is dark or invisible. This circle is called the circle of illumination. Which way must the earth rotate to make the sun rise in the east and set in the west, from right to left or from left to right?

(*3*) To determine the location of hour circles and meridians.
Upon how many degrees of the equator can the sun shine vertically in one day? In one hour? In four minutes? Through how many degrees does a point in latitude 30° north rotate in one day? In one hour? In four minutes?
Rotate the globe under the hoop, which marks the circle of illumination, to illustrate this movement of the illumination for one hour of rotation. How many degrees apart should lines be drawn, from pole to pole, to mark off the hours on the earth's surface? These may be called hour circles and are meridians. How many hour circles may there be? How many meridians may there be?

PROBLEMS IN LONGITUDE AND TIME.

a If the sun is just rising at 45° East longitude what will be the time before or after sunrise at 60° East longitude? What will be the time at 10° West longitude?
b If a telegram were sent from London, 0° longitude, at 10 P. M., to Chicago, 87° 37′ West longitude, at what time would it be received, allowing 30 minutes for transmission?
c When it is noon at Chicago it is 9:48 a. m. at San Francisco. What is the longitude of the latter?

(*4*) To locate the standard time belts in the United States.
On the outline map of the United States locate the meridians of 75°, 90°, 105°, and 120° W. Long. Why should these be chosen as the central meridians for the standard time belts? By referring to a standard time map, sketch in and name the four standard time belts. Explain the convenience of standard time.

PROBLEMS INVOLVING STANDARD TIME AND THE DATE LINE.

a What is the exact longitude of the place in which you live? To which of the central meridians of standard time are you nearest? How much does your standard time differ from your local time and why?

b If you should start at noon to-morrow and travel west around the earth at the same rate at which the earth rotates, what time and date would you count it when you had gone one-fourth the distance around? One-half the distance around? Three-fourths the distance around? The whole distance around? How would your date differ from those who had remained at home and how would you change your date to correct it?

c If you should start from home to-morrow at noon and travel east at the same rate at which the earth rotates, what time and date would you count it when you had gone 90° E.? 180° E.? 270° E.? 360° E.?

d When a person travels west how much and how often does he have to change his watch? How would he have to change his date to make up for this change of his watch if he went around the earth? How would he make these changes if he went east? Where would he change his date?

e On an outline map of the world draw the date line with its irregularities as shown on a map giving the date line. On the west side of the line write "Monday." Write the proper day on the east side of the line to correspond with the west side.

Name——————————————

Address——————————————

Exercise III.

A STUDY OF LATITUDE AND LONGITUDE.

Material. Pencil, compasses, ruler, globe.

(*1*) To represent by a map an eastern or western hemisphere, with latitude and longitude lines.

Draw a circle six inches in diameter. Mark dots directly above and below the center to represent the North and South poles respectively. Draw a prime meridian intersecting these three points. Draw a straight line, through the center, at right angles to the meridian to represent the equator. Divide each quadrant arc into three equal parts, as accurately as you can estimate. Divide the prime meridian into six equal parts. By connecting the points in the circumference with these points in the prime meridian, draw the curved lines which represent the parallel circles. Indicate tropical and polar circles, in their proper places, by means of dotted lines. Divide the equator into twelve equal parts; through these points draw meridians from pole to pole. Mark in degrees all latitude and longitude circles you have drawn. Name the tropical and polar circles.

(*2*) To represent by a map the northern hemisphere, with latitude and longitude lines.

Draw a circle six inches in diameter. From the center as the North pole draw 24 equidistant radii for meridians. (Suggestion: Divide the circumference into six equal parts by using the compasses, whose points are the radius distance apart. Bisect these arcs; then bisect again.) Draw the parallels of 30° and 60° by dividing the radii into three equal parts by concentric circles. Represent the Arctic circle and the Tropic of Cancer by means of dotted lines. Name all the lines as in the preceding drawing.

(*3*) Compare the two drawings made in this exercise with a globe placed in the positions represented. Notice in what particulars the drawings fail to represent perfectly the lines as they appear on the spherical surface.

Name——————————————————

Address——————————————————

Exercise IV.

OBSERVATION OF LATITUDE.

Material. Globe, horizon circle, quadrant instrument.

(*1*) To determine why the altitude of the North Star (Polaris) indicates the latitude of places in the northern hemisphere.

Place the horizon circle so that the crossing of the wires will be at the equator. The edge of the circle, extended, indicates the horizon line (where the earth and sky appear to meet) for an individual located on the equator, where the wires cross. How much of the heavens can be seen at one time from any one place on the earth? Where would the star which is above the north pole appear to be to a person located on the equator? As the person goes north one degree from the equator how does the North Star change its position with the horizon? Place the crossing of the wires at 10° N. How high above the horizon will the North Star appear to one at 10° N.? Make a conclusion as to how to find the latitude of a place in the Northern Hemisphere by observing the North Star.

(*2*) To determine the latitude of your locality by observation of the North Star.

On a clear night, find the horizon over a body of water or other plane, or go high enough to look off and see a regular horizon line. Find the North Star. With the quadrant instrument find the altitude of the star. Take the observation several times and average the results. Compare the observed altitude with the latitude given on a map for your location.

Name——————————————

Address——————————————

Exercise V.

REVOLUTION AND INCLINATION OF THE AXIS AND THEIR EFFECTS.

Material. Globe, a hoop of tin or other substance made to fit closely about the globe, a horizon disc, three outline maps of the Western Hemisphere.

(*1*) To determine where the vertical rays of the sun fall at different seasons and the effects: length of day and night, tropical and polar circles.

Place some object on the center of your desk to represent the sun. Incline the axis of the globe 23½° from the vertical. Place the globe a little distance from the sun so that the axis points towards the north. Carry the globe about the sun, in anticlockwise direction, to represent the annual movement of the earth about the sun. Place the globe in such a position that the vertical rays of the sun would shine vertically upon the equator. Call the season spring. Place the hoop about the globe to show what half of the earth is illuminated. How does the circle of illumination divide the equator? Rotate the globe. How many hours of sunlight would any place on the equator have on this twenty-first day of March? Then what is the relative length of day and night at the equator in the spring? What is the relative length of day and night for any place on the parallel of 45° N.? What is the relative length of day and night all over the earth on March 21st? Why is it called the Spring Equinox? Shade an outline map of the Western Hemisphere to show what part of it is light and what part is dark when it is noon at 20° W. Long. March 21st.

Carry the globe around in its orbit 90°, keeping the axis pointing to the north, to a point where the north pole is inclined toward the sun. Place the hoop to represent the circle of illumination on this day of June 21st. Where will the vertical rays of the sun fall on this day? Rotate the globe and note what line on the earth is traced by the vertical rays of the sun. What then is the meaning of the Tropic of Cancer? How far beyond the north pole does the sun shine on June 21st? Rotate the globe and note what part of the earth would not be in the sunlight on June 21st. What circle marks off this region? What is the condition of day and night within the Antarctic circle on June 21st? How much of the equator is illuminated at one time on June 21st? What is the relative length of day and night at the equator on June 21st? What is the relative length of day and night at 60° N. on June 21st? By counting the number of hour circles in the illuminated area on the 60th parallel state definitely the length of the day and of the night on June 21st. In the same way determine the length of day and night at your own latitude on June 21st. What is the relative length of day and night in the Northern Hemisphere on June 21st? What is the relative length of day and night in the Southern Hemisphere on June 21st? What is the meaning of Summer Solstice? Shade an outline map of the Western Hemisphere to show what part of it is light and what part is dark when it is noon at 20° W. Long. at the Summer Solstice.

Move the globe around 90° farther in its orbit, until the vertical rays of the sun fall on the equator. What date is it? What is the period called? What is the relative length of day and night all over the earth on this date?

Move the globe around 90° further in its orbit, until the north pole points away from the sun. At what latitude does the sun shine vertically at this Winter Solstice? What circle is determined by the vertical rays of the sun at this date? What is the relative length of day and night at the equator? What is the relative length of day and night in the Northern Hemisphere? In the Southern? Determine the exact length of day and night at your locality on December 21st. Shade an outline map of the Western Hemisphere to show what part of it is light and what part is dark when it is noon at 20° W. Long. on December 21st.

Make a drawing of the earth in its revolution about the sun showing the position of the earth's axis, and the halves of the earth illuminated at the four dates: March 21st, June 21st, September 21st, and December 21st.

(2) To determine the noon altitude of the sun at any place.

What is the altitude of the sun at the equator on March 21st? Place the globe in the proper position to represent the relative position of the earth and sun on the spring equinox. Place the horizon disc so that the wires cross on the equator. The sun at this date is vertical where? Count the number of degrees between the place where the rays fall vertically and the horizon of that place to determine the altitude of the sun at noon at that place. Make a diagram showing the angle made at the center of the earth, between the vertical rays and the horizon of the place.

PROBLEMS ON THE SUN'S ALTITUDE.

a Determine the noon altitude of the sun on March 21st, on June 21st, on September 21st, and on December 21st at each of the following places and express the answer by a diagram showing the angle made at the center of the earth, between the vertical rays and the horizon of that place:

Chicago, 42° N. Lat.
New Orleans, 30° N. Lat.
Pretoria, 26° S. Lat.
Your own locality.

b How far is your own locality from the vertical rays of the sun on June 21st? How far is the equator from the vertical rays of the sun on the same date?

c What are the latitudes of those places where the sun is 80° above the horizon on December 21st?

c What is the altitude of the sun at midnight in latitude 78° N. on June 21st?

d What is the latitude of that place where the sun is 3° above the horizon at midnight on December 21st?

e What is the lowest latitude where any day is more than 24 hours long?

Name————————————————

Address————————————————

Exercise VI.

MEASUREMENT OF DISTANCES ON THE EARTH'S SURFACE. GLOBE STUDY.

Material. Globe, pencil compasses.

(*1*) To determine approximately the number of miles in a degree on any parallel. If there are 360° in the equator and the earth is approximately 25,000 miles in circumference, what is the length, in miles, of one degree at the equator? What is the length of one degree on any meridian? What is the length of one degree at the polar point? What is the length of one degree on the parallel of 45°?

Determine the number of degrees between any two meridians on your globe. Spread your pencil compasses, so as to mark the exact distance between the two meridians on the 45th parallel. Lay off this same distance on the equator and find the number of equatorial degrees contained in the distance. Multiply the number of equatorial degrees so found by the number of miles in one equatorial degree. This will give you what distance? Divide the product by the number of degrees between the meridians at the 45th parallel. The result is what? Find how many miles per hour the earth rotates at the parallel of 45°. Determine and fill out the following table:

Number of Miles in One Degree.	Latitude.	Number of Miles Earth Rotates in an Hour.
	0	
	10	
	20	
	30	
	40	
	50	
	60	
	70	
	80	
	90	

Name——————————————

Address——————————————

Exercise VII.

OBSERVATIONS OF THE HEAVENS.

Material. Quadrant instrument, cross-ruled paper.

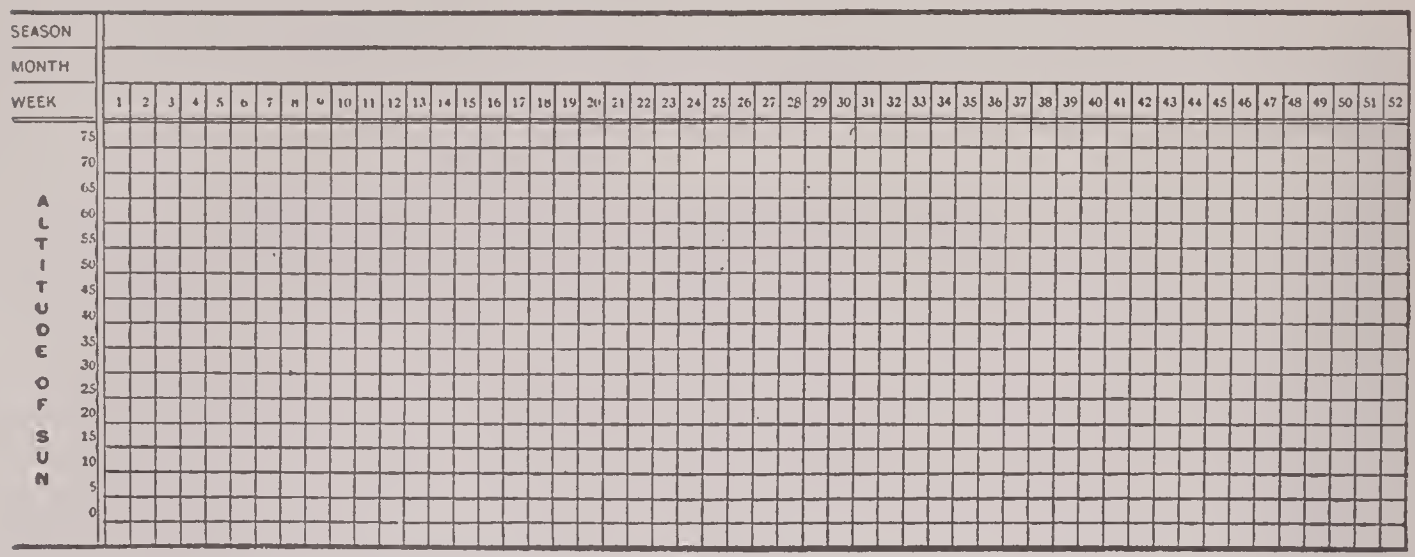
THE SUN.

(*1*) To determine the sun's altitude at different times of a day. On some one day, take the altitude of the sun just before school, again at noon (sun time), and again after school. Make a record of your observations and state the time and date each was taken.

(*2*) To determine the changes of position in the heavens and the time of rising and setting of the sun during the year. On the first clear day of each week, during the school year, observe the time and the direction of the rising sun and of the setting sun and the altitude of the sun at about noon. Record your observations in the following table. (If you are unable to make the observations regularly, get the data from an almanac to fill up the vacant places, but draw a small circle around the figures so obtained.):

DATE	RISING		SETTING		Noon Altitude
	Time	Direction	Time	Direction	

(3) To determine the curve of the sun's annual variation in altitude.
On the chart below make a dot, each week, in the proper place to show the noon altitude of the sun which you observed and recorded in the preceding table. Connect the dots by a line, which you may call the curve of the sun's annual variation in altitude. After you have completed a month's observations, write the name of the month above the numbers representing the weeks:



(4) To draw sunrise and sunset curves.
On a sheet of cross-ruled paper let the vertical lines one centimeter apart represent the first days of the months. Date each line from January 1st to January 1st, inclusive. The centimeter spaces will represent the months. Let the horizontal centimeter lines represent the hours of the day. Number the top one 12 midnight, the next one below 1 a. m., and so on down. Draw a heavy line across the page on the noon line.
Take from an almanac the times of sunrise and sunset, at your latitude, on the first of each month. Indicate these times by dots on your diagram in the proper places. The distance between the dots for a given day will represent the length of the day. Draw the sunrise and sunset curves by connecting the dots.
When is the day longest? When is the night longest? When are the day and night of equal length? How does the total time of daylight for the year compare with the total time of darkness? Why?

(5) To observe and record the phases of the moon.

During a month, designated by the teacher, make on drawing paper a series of drawings of the moon, showing its apparent shape on each Monday and each Thursday during the month. State the age of the moon at each drawing.

(6) To observe and record the changes of position which the moon undergoes during the month.

Observe the time and direction of the rising and of the setting of the moon on the days on which you make the drawings and record them in the following table. If you are unable to make all of the observations, supply the lacking data from an almanac, but draw a small circle around the figures so obtained:

Date	Time of Rising	Time of Setting	Phase	No. of Days Since New

Where is the sun when you observe the bright, new moon in the west? Make a drawing showing the relative positions of the sun, earth and moon at the time of new moon.

Where is the sun when you observe the full moon in the east? Make a drawing showing the relative positions of the sun, earth and moon at the time of full moon.

Explain why the "horns" of the moon always point away from the sun.

WEATHER OBSERVATIONS.

(7) To determine the cause and effect relations of weather changes and conditions.

Fill out one of the following charts each month, from observations taken approximately the same time each day:

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															

Date	Day	Hour of Day	Temperature	Barometric Pressure	Dry Bulb Thermometer	Wet Bulb Thermometer	Relative Humidity	Direction of Wind	Velocity of Wind	Percentage of Days Cloudy	Kinds of Clouds	Form of Precipitation	Amount of Precipitation	Frost, Dew or Clear	Sunset Colors Heavy, Light or No Coloration	Position of Storm Center.
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															

Name——————————————

Address——————————————

Exercise VIII.

LIGHT.

Material. Sticks of colored crayon; violet, indigo, blue, green, yellow, orange, red and white, a piece of glass, a sheet of white drawing paper, a metal cup.

(*1*) To determine the composition of different colors.

On a piece of rough, white paper fill in solid a small square of about two inches with the red crayon. Cover half of this square with yellow crayon and rub it well to mix it with the red underneath. What is the resulting color? What relation does the newly produced color bear to the others in the spectrum position? Repeat the exercise, making other squares by using the following pairs of colors: violet and blue, blue and yellow, green and orange.

(*2*) To determine the composition of shades.

Make other color squares, using the crayon with colors which stand next to each other in the spectrum. What is produced? In the same way mix one of the colors with white. What effect is produced?

(*3*) To observe the effect of refraction.

Put a coin in the bottom of a metal dish so that it is just beyond the range of vision as you look over the edge of the dish to the bottom of the opposite side. Fill the dish with water, pouring slowly to avoid disturbing the position of the coin. What is the effect of the water on the apparent position of the coin? Make a drawing which will show the course the light must have taken through the water and through the atmosphere to produce the effect.

EXERCISES FOR OUT-OF-DOORS OBSERVATION.

(*4*) To observe some of the natural phenomena of light.

a Hold a piece of glass closely over an oil flame or a candle flame until the glass is heavily coated with soot. Look through the glass at the sun. What color does the sun appear to be? Explain what has become of the other colors.

b Observe the full moon when near the rising or setting points when it looks abnormally large and red. Note what the atmospheric conditions are at the time. This appearance of the moon is often known as a "bloody moon" and is considered a sign of drought. Is there any reason for so considering it? Explain.

c Observe the sunset or sunrise colors and make a note of the arrangement of the colors. Which side of the spectrum is below? Give a reason for this.

d Just after the sun has set notice the "twilight arch" in the east. Note the clear blue space below the arch. This is the shadow of the earth. Account for it.

e Observe rainbows, coronas, "sun-dogs," etc., and make a note of the conditions which prevail when each is observed, the order of arrangement of the colors and give a reason for the light effect.

Name——————————————

Address——————————————

Exercise IX.

MAGNETISM.

Material. Two sewing needles, a small bar magnet with north and south ends marked, a tumbler of water, a piece of pith or cork, an outline map of North America, an isogonic map of the United States.

(*1*) To determine the magnetic properties of a magnet.

Place a sewing needle on a sheet of paper and toward it move, slowly, one end of a small bar magnet, noticing the distance at which attraction is first observed. Do the same with the other end of the magnet. Do the ends attract the needle equally? Rub the needle over the magnet a number of times in the same direction until the needle will itself attract another needle. Try each end of the magnet again on the point of the magnetized needle. Note the resulting attraction and repulsion.

(*2*) To manufacture a simple compass.

Cut a piece of pith or cork into a small disc about the size of a dime and a little thicker. Run the magnetized needle through the broad way of the disc until it is evenly balanced in the center of the disc. Place the needle and disc very carefully upon the quiet surface of a tumbler of water so that it floats. Let the needle come to rest away from the edge of the tumbler. Care should be taken to remove the bar magnet some distance from the needle. What direction does the needle assume? Determine the north and south line.

Bring the north end of the bar magnet near the north pointing end of your compass needle. What is the result? Bring the north end of the magnet to the south pointing end of the needle. What is the result? Bring the south end of the magnet to the north end of the needle. What is the result? Bring the south end of the magnet to the south end of the needle. What conclusion can you make concerning the attraction and repulsion of magnets?

(*3*) To determine the declination of the compass.

By referring to an isogonic map of the United States determine how far from the direct north polar point the magnetic needle points in your locality. On an outline map of North America locate the North Magnetic Pole. At your own locality mark an arrow showing the direction the magnetic needle points. Do the same for New York, Columbia, S. C., San Francisco and Portland, Ore.

Name————————————————

Address————————————————

Exercise X.

HEAT.

Material. Snow or ice, a tin can or a deep dish, a Fahrenheit thermometer, a test tube, a small flask, a rubber stopper with two holes, a stand, a sixteen-inch glass tube, a glass stopper-plug.

(*1*) To determine the freezing point of water.

Record the temperature of the water in a vessel of melting snow or ice.

Mix some cracked ice or snow with one-third its volume of salt and pack the mixture in a can or deep dish. Fill a test tube one-half full of ordinary water and bury it to an inch above the water level in this mixture. Put a thermometer in the water of the test tube and note the temperature at which ice forms. Repeat the experiment with water containing about three per cent of salt, the amount found in sea water. What is the result? What becomes of the heat of the water in the test tube? What is the freezing point of water?

(*2*) To determine the boiling point of water.

Fill a flask one-third full of water. Place the thermometer through one hole of the rubber stopper so the bulb of the thermometer will rest just above the surface of the water when the stopper is inserted in the flask. Arrange the flask over the flame and note the reading of the thermometer when the water boils. Remove the stopper and push the thermometer through so that the bulb will be in the water. Record the temperature of the water when boiling. Bring the flame closer and heat as intensely as possible. How high will the thermometer go? Cover the hole in the stopper just for an instant, not longer. What effect does this have on the temperature? What conclusion can you make concerning the effect of pressure on the boiling point of water?

(*3*) To determine the expansive effect of heat on a liquid.

Fill the flask full of water. Leave the thermometer in one hole of the stopper and put a piece of glass tubing through the other hole so that it will stand at least a foot above the stopper. Insert the stopper and allow the water to stand an inch or so high in the tube. Mark the water line with a piece of gummed paper. Heat the flask very slowly and note the distance the water rises in the tube for each degree of temperature read.

(*4*) To determine the expansive effect of heat on a gas.

Remove the thermometer from the stopper and fill the hole with a glass plug. Insert the glass tube through the other hole. Empty the flask and insert the stopper with its glass tube. Turn the flask so that the end of the tube is under water. Rub the flask vigorously with the hands. What is the effect? Warm the flask very slightly by bringing the flame near it. What is the effect? Allow the flask to cool slowly. What does this experiment prove concerning the effect of heat on a gas? Which will be the heavier, a cubic foot of cold air or a cubic foot of warm air?

Name——————————————

Address——————————————

Exercise XI.

TEMPERATURE OF THE EARTH'S SURFACE.

Material. Helior, several sheets of cross-section paper, Fahrenheit thermometer.

(*1*) To determine the relative amount of heat received from the sun at its different altitudes.

Place a piece of cross-section paper on the base board of the helior. Raise the tube of the helior until it is at an angle of 90° with the base. Look through the tube and see how much of the paper may be seen. This is the amount of surface the sunlight would cover if the sun were immediately over-head, with rays vertical. Outline this space on the paper. Adjust the helior so its base is horizontal and its tube is pointing directly at the sun. When the tube points directly at the sun, the largest possible space is covered by the sunlight on the base of the helior. Read the angle of altitude of the sun on the quadrant of the helior. Place a piece of cross-section paper on the base of the helior, as before, and outline the area lighted up. Count the number of square centimeters lighted when the sun is at 90° and at the last reading and place them in the table below. Place a thermometer, in a horizontal position, in the lighted area and note its temperature reading in the table below. Note also the temperature of the atmosphere. These temperatures must be taken out of doors.

(*2*) To determine the relative amount of heat received at different times of the day.

On some clear day, make observations with the helior at least three times during the day: Early in the morning, at noon, and late in the afternoon. Observe the amount of area lighted, the temperature of the lighted area, the temperature of the atmosphere as above and place the results in the table below. When does the light have the greatest effect, when the rays are most vertical or most oblique? Why? At what time of the day will the sun's heat be most effective? Call this maximum amount of area lighted 100 per cent. Divide the area at noon by the area covered at each of the other observations to find the percentage of area covered compared with the noon area.

Hour	Area Lighted in Square Centimeters	Helior Thermometer Reading	Percentage of Area Covered Compared with Noon Area	Temperature of Atmosphere

a On what noon of the year would the area lighted be the smallest? Where, on the earth, at that time would the sun's rays be concentrated over the smallest area? Find how many square centimeters would be illuminated under the helior on that noon at your locality.

b Find how many square centimeters would be illuminated at your locality under the helior at noon on December 21st.

Name————————————————

Address————————————————

Exercise XII.

TEMPERATURE OF THE EARTH'S SURFACE.

Material. A record of the hourly temperature for six consecutive days, several sheets of cross-section paper.

(*1*) To draw a daily temperature curve.

On the cross-section paper, one of the larger or centimeter square spaces from left to right should represent two hours. One centimeter space up and down should represent two degrees. Number the lines representing the hours and degrees. Dot, in its proper place, the temperature for each hour of the first day, then draw a line connecting the dots. Make one of these temperature curves for each day. Write the reasons for the regular changes of temperature shown by the curves and explain any irregularities.

When was the maximum temperature observed?

When was the minimum temperature observed?

What was the range of temperature for the week?

What was the average temperature for the day showing the maximum temperature?

Name——————————————

Address——————————————

Exercise XIII.

TEMPERATURE OF THE EARTH'S SURFACE.

Material. A blank United States weather map, 3 outline maps of the world on Mercator's Projection, an annual isotherm map of the world, a July and a January isotherm map of the world, an annual temperature range map of the world.

(*1*) To indicate places of the same temperature.

At a given hour the temperature of the following places was 57°: Seattle, Spokane, Helena, Miles City, Rapid City, Valentine, Lincoln, Keokuk, Springfield, Indianapolis, Cincinnati, Elkins, Washington. On a blank weather map of the United States draw a line connecting all of these places. Give this line its proper name which shall distinguish what it stands for.

(*2*) To make an annual isotherm chart of the world.

Upon an outline map of the world draw the annual isotherms of 80°, 70°, 60°, 50°, 40°, 30°, 20°, 10° and 0°.

Shade or color darkly all surface having an annual average temperature of 70° or over. With lighter shadings indicate the regious having a temperature between 70° and 30°. With a very light shading indicate the regions having a temperature between 30° and 10°. Upon or near what annual isotherm is your locality situated? Find other places, at some distance, on the same isotherm. Do all places on the same annual isotherm necessarily have the same climate?

(*3*) To indicate the extreme locations of the heat equator.

On an outline map of the world indicate the location of the heat equator in January by making a heavy dotted line. Indicate the location of the heat equator for July by making a continuous line. Explain why the heat equator oscillates with the time of the year. Where and when does the heat equator depart farthest from the geographic equator? Explain this great departure at this time and place.

(*4*) To indicate the annual average range of temperature.

On an outline map of the world represent the annual average range of temperature by shading or coloring those regions which have less than 20° range, those between 20° and 50°, those between 50° and 110°, those over 110°. Where are the ranges greatest, over land or sea? Where is the greatest range of temperature? Account for its location. Account for the range of temperature being smaller in the Southern than in the Northern Hemisphere.

Name——————————————————

Address——————————————————

Exercise XIV.

TEMPERATURE OF THE EARTH'S SURFACE.

Material. A blank weather map of the United States.

(*1*) To represent the daily isotherms of the United States on a specified day.

Observations Taken at 8 A. M., 75th Meridian Time.

Districts and Stations.	Barometer readings, in inches.	Temperature.	Wind direction and velocity in miles per hour.	Sky and precipitation.
Atlantic Coast.				
Boston	30.46	34	S. E. 12	cloudy
Albany	30.34	32	S. E. 20	"
New York	30.32	38	E. 34	"
Philadelphia	30.24	40	S. E. 14	rain
Washington	30.16	36	N. Lt.	"
Lynchburg	30.12	36	N. E. Lt.	"
Norfolk	30.12	42	N. Lt.	"
Jacksonville	30.12	66	S. 8	clear
Tampa	30.14	68	S. E. 12	cloudy
Gulf States.				
Atlanta	30.02	50	N. E. 6	rain
Mobile	30.06	70	S. W. Lt.	fair
Montgomery	29.98	70	S. 12	cloudy
Vicksburg	30.08	62	N. W. 12	fair
New Orleans	30.06	70	S. W. 6	"
Shreveport	30.14	54	N. W. 8	clear
Fort Smith	30.16	38	W. 12	"
Little Rock	30.06	48	W. 12	fair
Galveston	30.06	66	N. W. 6	cloudy
Palestine	30.18	52	N. E. 6	"
San Antonio	30.04	62	N. 14	"
Fort Worth	30.24	42	N. 8	fair
Ohio Valley and Tenn.				
Indianapolis	29 64	56	S. W. 28	clear
Pittsburg	29.88	42	S. 6	rain
Cincinnati	29 74	58	S. 14	cloudy
Columbus	29.72	54	S. 12	"
Louisville	29.76	58	S. 14	"
Chattanooga	29.98	50	S. E. Lt.	rain
Memphis	30.02	56	W. 14	fair
Nashville	29.92	60	W. 8	cloudy
Parkersburg	29.82	50	S. E. 14	"
Lake Region.				
Chicago	29.54	40	S. W. 36	cloudy
Detroit	29.64	42	S. 10	"
Grand Haven	29.50	40	S. 12	"
Marquette	29.68	24	W. 12	snow
Sault Ste. Marie	29.62	24	E. 14	"
Duluth	29.90	26	N. W. 18	"
Cleveland	29.68	48	S. E. 30	rain
Buffalo	29.78	40	S. 18	cloudy
Parry Sound	29.74	28	S. E. 36	"
White River	29.80	18	N. Lt.	snow

Districts and Stations.	Barometer readings, in inches.	Temperature.	Wind direction and velocity in miles per hour.	Sky and precipitation.
Upper Miss. Valley				
Cairo	29.88	54	S. W. 20	clear
St. Louis	29.84	40	W. 28	cloudy
Springfield, Ill.	29.74	38	W. 20	"
Keokuk	29.84	36	W. 26	"
Davenport	29.62	34	W. 16	rain
Des Moines	29.96	28	N. W. 20	cloudy
Dubuque	29.64	32	N. W. 20	snow
St. Paul	29.88	24	N. W. 16	fair
Missouri Valley.				
Kansas City	30.08	32	N W. 12	cloudy
Springfield, Mo.	30.10	28	N. W. 26	clear
Concordia	30.30	30	N. W. 24	"
Omaha	30.10	24	N. W. 16	cloudy
Sioux City	30.12	18	N. W. 28	"
Huron	30.20	10	N W. 30	"
Bismark	30.58	— 4	N. W. 8	clear
Moorhead	30.30	8	N. W. 20	cloudy
Northwest Territory				
Calgary	30.62	—16	0	clear
Minnedosa	30.70	—12	S. W. Lt.	"
Prince Albert	30.68	—32	0	fair
Swift Current	30.72	—12	0	cloudy
Qu' Appelle	30.64	— 6	Lt.	"
Rocky Mt. Slopes.				
Havre	30.42	*zero*	N. E. 8	clear
Helena	30.40	2	W. Lt.	snow
Miles City	30.50	2	N. Lt.	fair
Rapid City	30.50	4	N. E. 6	"
Valentine	30.48	4	N. W. 12	clear
North Platte	30.48	8	N. W. 14	"
Cheyenne	30.46	8	S. 8	"
Lander	30.36	4	S. W. Lt.	cloudy
Salt Lake City	30.00	40	S. E. 6	"
Denver	30.38	14	N. E. 18	clear
Pueblo	30.30	18	E. Lt.	fair
Santa Fe	30.18	24	0	clear
El Paso	30.14	30	N. E. Lt.	"
Abilene	30.26	36	N. 6	"
Amarillo	30.30	22	N. 14	"
Oklahoma	30.24	30	N. 14	"
Dodge City	30.38	18	N. W. 12	"
Wichita	30.30	24	N. W. 14	"
Grand Junction	30.14	32	E. 20	cloudy

The temperature for all important stations will be found in the above table. Place the temperature in figures on a blank weather map of the United States. Draw the isotherms for every ten degrees, using a pencil and making light lines. When the isotherms are finished and the work has been reviewed, trace the lines with ink.

Name——————————————————

Address——————————————————

Exercise XV.

SOME EFFECTS OF BAROMETRIC PRESSURE.

Material. Pneumatic trough, large-mouthed bottle, piece of cardboard 4 x 4 in.

(*1*) To show the pressure of the atmosphere.

Fill the pneumatic trough with water. Invert the empty bottle under water in the trough. What is the water replacing? Turn the bottle bottom-side up and draw it up until only its mouth remains under water. Make a drawing showing by means of arrows, where the pressure is exerted which holds the water in the bottle. Draw the bottle fully out of water. Why does not the pressure still hold the water in the bottle?

(*2*) To demonstrate that the pressure is exerted in every direction.

Fill the bottle full to running over. Dampen the cardboard and place it on the mouth of the bottle and press it down gently. Take hold of the bottle and slowly turn it up-side down. Turn it in every direction. What conclusion can you draw concerning the pressure of the atmosphere?

PROBLEMS.

a· Take a piece of soft leather like the top of a shoe. Cut it into a round piece about three inches in diameter. Tie a knot in the end of a three-foot string and put it through the leather so that the knot holds it firmly from slipping through. Moisten the leather thoroughly and a "sucker" has been made. Press it firmly against a smooth rock or tin can. How much weight will it hold up?

b Examine a pump or a syringe. Make a drawing of it which will show how its piston works and write an explanation of how the atmospheric pressure causes it to "suck up" water. Find out how high a pump will draw water.

c Examine a mercurial barometer carefully and make a drawing of it which will indicate how the pressure of the atmosphere causes the height of the mercury to vary.

Name——————————————

Address——————————————

Exercise XVI.

BAROMETRIC CURVES AND VARIATIONS.

Material. One sheet of cross-section paper, a barometric record for two consecutive weeks.

(*1*) To draw a barometric curve representing the change in barometric pressure for two weeks.

By referring to your weather observations, Exercise VII, select two consecutive weeks in which the barometric pressure shows considerable variation. On cross-section paper draw the barometric curve for the two weeks. One of the centimeter squares, from left to right, should represent one day; and each heavy line, up and down, should represent one-tenth of an inch. Number the lines and date the spaces to correspond with the barometric readings and the date indicated in your table. In its proper place, dot in the barometric reading for each day. Draw a line connecting the dots. Underneath the curve thus made, indicate the condition of the weather for the day, whether fair, cloudy or stormy. How does the barometric pressure tend to vary with the humidity?

Name——————————————

Address——————————————

Exercise XVII.

A STUDY OF THE EARTH'S BAROMETRIC PRESSURE.

Material. A chart showing the annual isobars of the earth, an outline map of the world.

(*1*) To indicate graphically the earth's annual average barometric pressure.

On an outline map of the world on Mercator's Projection draw the isobars for every one-tenth of an inch variation in annual average barometric pressure, over the earth's surface. Shade or color darkly those regions having a pressure of over 30 inches and shade or color lightly those regions having a pressure less than 29.9 inches. What latitudes show the highest pressure? How does the equatorial low pressure area correspond to the region of the heat equator? (See Exercise XIII. 3.)

Name——————————————————

Address——————————————————

Exercise XVIII.

BAROMETRIC CHART OF THE UNITED STATES.

Material. A blank weather map of the United States, a list of the barometric pressures at various points in the United States. (See Exercise XIV.)

(*1*) To represent the barometric pressure over the United States on some specified day and hour by means of isobars.

Upon a blank weather map of the United States copy the barometric readings given in the table of Exercise XIV. for the various stations. Mark the areas where the pressure is lowest with the word "Low" and mark the areas where the pressure is highest with the word "High." Beginning with the centers of low pressure connect the places of equal pressure with isobars extending around the center, making isobars for every one-tenth of an inch. The isobars of high pressure should extend around the high pressure areas.

Name——————————————

Address——————————————

Exercise XIX.

AIR CURRENTS AS AFFECTED BY PRESSURE.

Material. An empty paste-board box, a piece of candle, a piece of cotton string soaked in saltpeter and dried, matches.

(*1*) To demonstrate the effect of temperature and expansion of air upon the direction of air currents.

Stand the pasteboard box on one end with the cover removed. In the top end cut a hole about an inch square. In the back of the box, about an inch from the bottom, cut another hole about an inch square. Place the candle in the center of the bottom end of the box. Light the candle and put the cover on the box. Light the string and hold it over the top hole. What is the direction of the air current? Hold the lighted string near the lower opening. What is the direction of the air current? Remove the cover and blow out the candle. After replacing the cover place the lighted string near the holes as previously. Are the air currents still present? Make a drawing of a longitudinal section of the box and indicate by arrows the direction of the air currents through the box, How does heat affect the volume of a body of air? (See Exercise X., 4.) Why should heated air be lighter than cooler air? Why should light air tend to rise? What will take the place of the light air?

(*2*) To determine and indicate the direction of winds about high and low pressure areas.

On the map in Exercise XVIII. you have indicated where the air is light and where the air is heavy, what then should be the direction of the atmospheric currents in the center of the low area? What should be the direction of the atmospheric currents in the center of the high area? On this map indicate, by means of a few arrows, the direction the atmosphere should be moving in the regions surrounding the low areas and around the high areas. Compare your determinations with the observed data in the table of Exercise XIV.

Name—————————————————

Address————————————————

Exercise XX.

PLANETARY WINDS.

Material. Isothermic and isobaric charts of the world from Exercises XIII. and XVII., a United States pilot chart, an outline map of the world.

(*1*) To determine the location and direction of the equatorial planetary winds from temperature and pressure data.

Study your isothermic and isobaric maps, Exercises XIII. and XVII., and determine the following: According to what you know of the effects of temperature and pressure on air currents what should be the direction of the air currents at the equatorial low pressure area? What should be the direction of the currents at the high pressure areas north and south of the equator? What should be the relative direction of the currents between these high and low pressure areas at the surface of the earth? What should be the relative direction of the currents between the high and low pressure areas in the upper atmosphere? Indicate the answers to these questions on a drawing of a sphere by showing the convection current in arrows at the side of the sphere.

(*2*) To determine the location and direction of the planetary winds of the different latitudes from observed data.

The blue arrows on the United States pilot charts indicate the direction of the wind. The longer an arrow is the more frequently is the wind from that direction indicated. The more "feathers" there are on an arrow the stronger is the wind. Observe a belt in a low latitude (note what latitude) having variable winds, i. e., winds from many directions. The figures in the circles indicate the per cent of time the place is calm or free from horizontal air currents; is the per cent great or small in this equatorial belt? The region having these characteristics is called the Belt of Calms or Doldrums. How does the location of the Belt of Calms compare with the equatorial low pressure area? Outline this Belt of Calms on an outline map of the world. North and south of the Belt of Calms is a belt of winds called the Trade Winds; the north and south boundaries are marked by dash lines. From what prevailing directions do the Trade Winds blow? Are they strong or light winds? Is it calm much or little of the time in this belt? How does the location of these Trade Wind Belts correspond with the location of the region lying between the high and low pressure regions? Outline the Trade Wind Belts on the outline map. North of the Trade Winds is the Horse Latitude Belt. In what latitude is it? From what direction are the winds? Are the winds strong or light? Is the region more or less calm than the Trade Wind Belt? How does the location of the Horse Latitudes correspond to the areas of high pressure? Outline the Horse Latitudes on the map. Still further north are the Prevailing Westerlies, merging into the Circumpolar Whirl. What is the direction and strength of the winds in the Belt of the Prevailing Westerlies? Outline the Belts of the Prevailing Westerlies and the Circumpolar Whirl on the map. Fill in the regions you have outlined on the map by determining the direction of the winds as given on the pilot chart. Use arrows to indicate the direction of surface winds, small circles for calms where currents usually ascend or descend and small crosses for belts of greatly varying winds. Compare your map with the Planetary Wind map in your text and complete the wind belts over the earth's surface.

Name——————————————

Address——————————————

Exercise XXI.

ATMOSPHERIC MOISTURE.

Material. A small pie tin, one small tin cup, two watch glasses, one glass tumbler.

To determine some of the things upon which evaporation depends.

(*1*) Put about an inch of water in the tin cup. Pour the water into a pie tin and pour the same amount of water into the cup. Place the two vessels near together where they may be observed from time to time. From which vessel does the water evaporate fastest? What effect has the amount of surface exposed upon the rate of evaporation?

(*2*) Put a few drops of water in each of the watch glasses, but allow the amounts in each to be equal. Place one vessel where it will be out of any draught, but easily observed. Fan or blow the other for some minutes. From which vessel does evaporation take place the more rapidly? What effect have moving air currents, over a body of water, upon the rate of evaporation? Explain why this should be so.

(*3*) Put equal amounts of water in the watch glasses. Place them in a safe place near together. Invert the glass tumbler over one and leave the other exposed. What collects on the inside of the tumbler? From which vessel does evaporation take place the more rapidly? What effect has moist atmosphere upon the rate of evaporation?

(*4*) What effect has high temperature upon evaporation? Give an illustration to prove your answer.

Name——————————————————

Address————————————————

Exercise XXII.

ATMOSPHERIC MOISTURE.

Material. A flask, a square of glass, a tin cup, a thermometer, some cracked ice or snow.

To determine the conditions under which condensation takes place.

(*1*) Heat some water in the flask until steam arises. Hold the cool square of glass over the steam. What collects on the glass? Where does it come from? Why does it collect?

(*2*) Be sure the tin cup is dry on the outside, then fill it with water and put some ice or snow in the water. What collects on the outside of the cup? Where does it come from? Why does it collect? Empty and dry the cup. Fill it three-fourths full of water. Put the thermometer bulb in the water. Drop ice into the cup, one small piece at a time, and stir with the thermometer. Keep watch for the condensation on the outside of the cup. Note the temperature of the water at the moment when the outside of the cup shows the first sign of condensation? This temperature is called the "dew point." Try the experiment out of doors, in other rooms and on other days to see if the dew point is always the same? How does the temperature of the atmosphere seem to affect the dew point? How does the amount of moisture in the air seem to affect the dew point?

Name——————————————————

Address————————————————

Exercise XXIII.

ATMOSPHERIC MOISTURE.

Material. Three large-mouth bottles, 8 oz., 4 oz. and 2 oz., respectively.

(*1*) To illustrate the meaning of relative and absolute humidity.

Fill the 2-oz. bottle with water and pour it into the 8-oz. bottle. In the same way put 2 ounces of water in each of the bottles. What is the capacity of the 8-oz. bottle? What is the absolute amount of water in the 8-oz. bottle? This is the absolute humidity of the bottle. What is the relative amount of water in the 8-oz. bottle, compared with its capacity? This is the relative humidity of the bottle. Write a definition of your own for each of the following terms: Capacity, absolute humidity, relative humidity. Of the 4-oz. bottle tell its capacity, its absolute humidity in ounces and its relative humidity in per cent. Why is the relative humidity of the 4-oz. bottle greater than the relative humidity of the 8-oz. bottle? Of the 2-oz. bottle tell its capacity, its absolute humidity, and its relative humidity. What would happen if more water were put into the 2-oz. bottle? When the relative humidity of the atmosphere is 100% what would happen if more water entered into it? What would happen if the 2-oz. bottle could be squeezed so its capacity were less than 2 oz.? What happens when the relative humidity of the atmosphere is 100% and the capacity of the atmosphere is made less? By referring to Exercises XXII. and X., 4, tell what usually causes the lessening of the capacity of the atmosphere.

Name——————————————————

Address——————————————————

Exercise XXIV.

ATMOSPHERIC MOISTURE.

Material. Two Fahrenheit thermometers, a piece of cardboard three inches longer than the thermometers and three inches wide, a piece of cotton cloth one inch wide and four inches long, a small vial, pieces of thread.

(*1*) To construct and use a hygrometer, or wet and dry bulb thermometer. Place one end of the piece of cloth around the bulb of one thermometer and tie it on with a piece of thread. Place the two thermometers on the cardboard, about two inches apart, so their tops come to the top of the cardboard. Fasten them onto the cardboard securely by tying thread around them and through the cardboard. Put the end of the cloth into the vial and fasten the vial securely to the cardboard in such a position that the vial will be directly under the thermometer with the covered bulb, but that the vial and the bulb will not touch. Hang the hygrometer, thus made, in a vertical position. Note the reading of the two thermometers; they should register equal temperatures. Fill the vial with water which has been standing in the room long enough to be at the room temperature. Moisten the cloth wick on the bulb of the wet-bulb thermometer. Fan the hygrometer for a moment and note the temperature of the thermometer again. What causes the difference in their reading? Will the water evaporate faster when the air in the room is dry or humid? Will the wet-bulb thermometer register lower when air is dry or when the air is humid? Explain why. Of what does the dry-bulb thermometer register the temperature?

(*2*) To determine the relative humidity of the room. Fan the hygrometer and very carefully determine the reading of the wet-bulb and of the dry-bulb thermometers. Make a note of these temperatures and determine the difference in temperature readings. To find the relative humidity use the table below. In the top line find the number indicating the difference in temperature which you have observed. In the first column find the number indicating the temperature registered by the dry-bulb thermometer. The figure at the intersection of the two lines, traced down and across respectively, is the percent of moisture in the atmosphere of the room or the relative humidity.

TABLE FOR FINDING RELATIVE HUMIDITY: PERCENTAGES

Dry therm. (air temp.)	DIFFERENCE BETWEEN DRY AND WET-BULB THERMOMETERS.																																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
0	68	35	3																																						
2	71	41	12																																						
4	73	46	19																																						
6	75	50	25	1																																					
8	77	54	31	9																																					
10	79	57	36	15																																					
12	80	60	41	21	3																																				
14	82	63	45	27	10																																				
16	83	66	49	33	16	0																																			
18	84	68	53	38	22	7																																			
20	85	70	56	42	28	14																																			
22	86	72	59	45	32	19	7																																		
24	87	74	61	49	36	24	12	0																																	
26	83	75	64	52	40	29	18	7																																	
28	88	77	66	55	44	33	23	12	2																																
30	89	78	68	57	47	37	27	17	8																																
32	90	79	69	60	50	41	31	22	13	4																															
34	90	81	72	62	53	44	35	27	18	9	1																														
36	91	82	73	65	56	48	39	31	23	14	6																														
38	91	83	75	67	59	51	43	35	27	19	12	4																													
40	92	84	76	68	61	53	46	38	31	23	16	9	2																												
42	92	85	77	70	62	55	48	41	34	28	21	14	7	0																											
44	93	85	78	71	64	57	51	44	37	31	24	18	12	5																											
46	93	86	79	72	65	59	53	46	40	34	28	22	16	10	4																										
48	93	87	80	73	67	60	54	48	42	36	31	25	19	14	8	3																									
50	93	87	81	74	68	62	56	50	44	39	33	28	22	17	12	7	2																								
52	94	88	81	75	69	63	58	52	46	41	36	30	25	20	15	10	6	0																							
54	94	88	82	76	70	65	59	54	48	43	38	33	28	23	18	14	9	5	0																						
56	94	88	82	77	71	66	61	55	50	45	40	35	31	26	21	17	12	8	4																						
58	94	89	83	77	72	67	62	57	52	47	42	38	33	28	24	20	15	11	7	3																					
60	94	89	84	78	73	68	63	58	53	49	44	40	35	31	27	22	18	14	10	6	2																				
62	94	89	84	79	74	69	64	60	55	50	46	41	37	33	29	25	21	17	13	9	6	2																			
64	95	90	85	79	75	70	66	61	56	52	48	43	39	35	31	27	23	20	16	12	9	5	2																		
66	95	90	85	80	76	71	66	62	58	53	49	45	41	37	33	29	26	22	18	15	11	8	5	1																	
68	95	90	85	81	76	72	67	63	59	55	51	47	43	39	35	31	28	24	21	17	14	11	8	4	1																
70	95	90	86	81	77	72	68	64	60	56	52	48	44	40	37	33	30	26	23	20	17	13	10	7	4	1															
72	95	91	86	82	78	73	69	65	61	57	53	49	46	42	39	35	32	28	25	22	19	16	13	10	7	4	1														
74	95	91	86	82	78	74	70	66	62	58	54	51	47	44	40	37	34	30	27	24	21	18	15	12	9	7	4	1													
76	96	91	87	83	78	74	70	67	63	59	55	52	48	45	42	38	35	32	29	26	23	20	17	14	12	9	6	4	1												
78	96	91	87	83	79	75	71	67	64	60	57	53	50	46	43	40	37	34	31	28	25	22	19	16	14	11	9	6	4	1											
80	96	92	87	83	79	76	72	68	64	61	57	54	51	47	44	41	38	35	33	29	27	24	21	18	16	13	11	8	6	4	1										
82	96	91	87	83	79	76	72	69	65	62	58	55	52	49	46	43	40	37	34	31	28	25	23	20	18	15	13	10	8	6	4	1									
84	96	92	88	84	80	77	73	70	66	63	59	56	53	50	47	44	41	38	35	32	30	27	25	22	20	17	15	12	10	8	6	4	2								
86	96	92	88	84	80	77	73	70	66	63	60	57	54	51	48	45	42	39	37	34	31	29	26	24	21	19	17	14	12	10	8	6	4	2							
88	96	92	88	85	81	78	74	71	67	64	61	58	55	52	49	46	43	41	38	35	33	30	28	25	23	21	18	16	14	12	10	8	6	4	2						
90	96	92	88	85	81	78	74	71	68	64	61	58	56	53	50	47	44	42	39	37	34	32	29	27	24	22	20	18	16	14	12	10	8	6	4	2	0				
92	96	92	89	85	82	78	75	72	69	65	62	59	57	54	51	48	45	43	40	38	35	33	30	28	26	24	22	19	17	15	13	11	9	8	6	4	2	0			
94	96	92	89	85	82	78	75	72	69	66	63	60	57	54	52	49	46	44	41	39	36	34	32	29	27	25	23	21	19	17	15	13	11	9	8	6	4	2	1		
96	96	93	89	86	82	79	76	73	70	67	64	61	58	55	53	50	47	45	42	40	37	35	33	31	29	26	24	22	20	18	17	15	13	11	9	7	6	4	3	1	
98	96	93	89	86	82	79	76	73	70	67	64	61	58	56	53	51	48	46	43	41	39	36	34	32	30	28	26	24	22	20	18	16	14	13	11	9	7	6	4	3	1
100	96	93	90	86	83	80	77	74	71	68	65	62	59	57	54	52	49	47	44	42	40	37	35	33	31	29	27	25	23	21	19	18	16	14	12	11	9	7	6	4	3

(3) To determine the absolute humidity of the air in the room.
The following table gives the capacity, in grains, of one cubic foot of atmosphere at the different temperatures:

Degrees of Temperature.	Grains of Water.	Degrees of Temperature.	Grains of Water.	Degrees of Temperature.	Grains of Water.	Degrees of Temperature.	Grains of Water.
20	1.235	42	3.064	64	6.563	86	13.127
22	1.355	44	3.294	66	7.009	88	13.937
24	1.483	46	3.539	68	7.480	90	14.790
26	1.623	48	3.800	70	7.980	92	15.689
28	1.773	50	4.076	72	8.508	94	16.634
30	1.935	52	4.372	74	9.066	96	17.626
32	2.113	54	4.685	76	9.655	98	18.671
34	2.279	56	5.016	78	10.277	100	19.766
36	2.457	58	5.370	80	10.934		
38	2.646	60	5.745	82	11.626		
40	2.849	62	6.142	84	12.356		

The relative humidity, which you have obtained, shows what proportion of the capacity of the atmosphere is occupied with moisture. Find from the above table what the capacity of the atmosphere is at the observed temperature. Then find how many grains of moisture are actually in a cubic foot of air in the room. How many more grains could each cubic foot hold?
Determine and tabulate the following data for the following places:

Place	Dry Bulb Reading	Wet Bulb Reading	Difference in Temperatures	Relative Humidity	Absolute Humidity
School room					
Out doors					
Sleeping room (at home)					

Name——————————————

Address——————————————

Exercise XXV.

ATMOSPHERIC MOISTURE.

Material. Two copper or tin vessels with straight sides about six inches high and square or round bottoms, the bottom of one should be one-tenth the diameter of the other. A small ruler marked in inches. A blank relief map of the United States.

(*1*) To measure the amount of rainfall with a simple rain gauge.

Set the larger vessel in an open place away from buildings or other obstructions. After a rain measure the amount of water in the vessel by putting the ruler into the water. Note the result. Drain the water into the smaller vessel without spilling any of it. Measure its depth. Compare the reading with that of the first measurement. An inch on the ruler, when measured in the smaller vessel, measures how much rainfall? What is the object of pouring the water into the smaller vessel?

Keep your rain gauge exposed and note the amount of daily precipitation in your weather observation tables.

(*2*) To comprehend the annual amount of rainfall over the United States.

By consulting the United States annual rainfall chart in your text outline the following areas of rainfall on a blank relief map of the United States. Note what mountains and other topographic features form the boundaries for the different regions.

Outline the regions having an annual rainfall of over 60 inches, regions having between 50 and 60 inches, between 30 and 50 inches, between 10 and 30 inches and those having less than 10 inches. Shade or color the regions to correspond with the amount of annual rainfall. What is the annual rainfall of your locality? In going south along the Pacific coast from Oregon how does the rainfall vary? In going south along the Atlantic coast from Maine how does the rainfall vary? In going east across the United States from Great Salt Lake to the Atlantic coast how does the rainfall vary?

Give the reasons for the rainfall conditions on the windward side of mountain ranges, on the leeward side of mountain ranges, and in regions surrounded by mountain ranges.

Name————————————————

Address————————————————

Exercise XXVI.

STORMS, CYCLONES AND ANTI-CYCLONES.

Material. A number of United States weather maps arranged in consecutive order, a sheet of thin tracing paper, a blank weather map of the United States.

(*1*) To determine the general direction of the wind in a cyclonic or "low" area.

Place a piece of tracing paper, about two inches square over the "LOW" of a weather map. Write "LOW" in the middle and "N" at the upper margin. Trace all arrows indicating wind direction which your paper covers. Place the same paper over the "LOW" in another map, being careful to center the paper as before and to have the "N" to the north. Trace the arrows indicating the direction of the wind. Repeat on other maps until your tracing paper is covered with arrows. Paste the paper in your note book and write a statement of the atmospheric currents near the low area and at the storm center. Explain why the wind direction is as you find it indicated.

(*2*) To determine the general direction of the wind in an anti-cyclonic area or "high" area.

Use a piece of tracing paper on the "HIGH" as indicated above and record the data. Explain why the wind direction is as you find it in "high" areas.

(*3*) To determine the general temperature conditions under cyclonic and anti-cyclonic conditions.

Choose a number of maps which show observations taken during the same season of the year. In one column write down the temperature which is indicated nearest the center of each "low" area which happens to be in the central Mississippi Basin. Find the average temperature of "low" areas for this season of the year in the central Mississippi Basin. In the same way write down the temperature nearest the center of "high" areas in the central Mississippi Basin and find their average. When does the higher temperature prevail when a cyclone or anti-cyclone passes over a locality? Give a reason for this condition.

(*3*) To determine the position of rainy areas in relation to the cyclones and anti-cyclones.

Observe in many weather maps the area in which rain or snow is falling at the time of observation. How large are the districts? What is their position with reference to the "low" or "high" areas? Observe the extent and relative location of the cloudy areas. Give reasons why the rainy and cloudy areas should be thus located in reference to the "low" areas.

(*4*) To determine the paths of cyclonic storms over the United States.

Choose weather maps of several consecutive days through which a distinct storm persists. On a blank United States map draw a small circle where the "low" area is located on the weather map. Write the date of the weather map in the circle. On the same blank map make another circle and date in the position of the "low" area on the succeeding day. Connect the two circles by a line of arrows. Continue as many days as the "low" area is visible. Your line of arrows marks the path of the storm. In this way and on the same map, trace several storm paths at different seasons. How many miles a day do the storms move on the average? Over what part of the United States do most of the cyclonic storms originate? Describe their usual path. Over what other parts of the United States do the storms originate? Where do they pass off from the United States?

(*5*) To indicate the location of storms on the weather map.

Turn to your United States isobaric map (Exercise XVIII.) and shade the regions lightly where conditions indicate that cloudy weather prevails. Shade the regions darkly where the conditions indicate there should be rain. Compare the regions you have shaded with the data concerning the regions in the table of Exercise XIV.

Name——————————————

Address——————————————

Exercise XXVII.

STORMS—WEATHER FORECASTS.

Material. A United States weather map with the forecast cut off.

(*1*) To interpret a weather map.

Reading from the weather map, determine and tabulate below the conditions existing, in your own locality, at the time the observations were taken:

Temperature: degrees.

Barometric pressure: inches.

Wind direction:

State of humidity: Fair, cloudy, rain or snow.

(*2*) To forecast conditions from a weather map.

Forecast what the weather conditions will be, at your locality, twenty-four hours after the time of the observations indicated on the map.

Temperature: degrees.

Barometric pressure: inches.

Wind direction:

State of humidity:

Name——————————————

Address——————————————

Exercise XXVIII.

RAINFALL OF THE EARTH.

Material. An outline map of the world on Mercator's projection.

(*1*) To determine the theoretical rainfall of the earth.

By applying the principles of rainfall, learned by the study of local "high" and "low" areas, to the conditions existing over the earth you should be able to determine approximately the rainfall over the earth's surface. Consult your maps of the earth's annual temperature (Exercise XIII., 4), barometric pressure (Exercise XVII.), and planetary winds (Exercise XX.) and determine what regions of the earth would have the heaviest, lightest and moderate rainfall. Indicate these regions on an outline map of the world and indicate their approximate rainfall by shading the regions to correspond.

Name——————————————

Address——————————————

Exercise XXIX.

RAINFALL OF THE EARTH.

Material. A relief map of each of the continents, a chart or maps showing the amount of rainfall on each continent.

(*1*) To comprehend the location of the rainfall regions of the earth and the causal conditions determining the rainfall of each region.

On each of the relief maps of the continents outline and shade or color the regions of annual rainfall of over 80 inches, between 40 and 80 inches, between 20 and 40 inches, less than 20 inches, as they are shown in your rainfall maps. As you outline each region note what annual temperature, pressure and planetary winds prevail in the region and what conditions of topography influence the amount of rainfall. Write these causal conditions in full for each region in each continent.

Name————————————————

Address————————————————

Exercise XXX.

LIFE CONDITIONS OF THE EARTH.

Material. A map showing the life belts of the earth.

(*1*) To determine the causal conditions for the location of the life belts of the earth.

On the map note the location of each of the characteristic life belts: The Tropical Forest, The Tropical Savanna Belts, The Tropical Desert Belts, The Trade Wind Coasts, The Temperate Agricultural Regions, The Temperate Plains, The Temperate Deserts, The Northern Forest Belt and The Northern Tundra Belt. Of each of the belts tell its annual average temperature, its annual average barometric pressure, its location relative to the planetary winds, its annual average rainfall and tell something of its characteristic vegetation, animal life and social life. Tabulate all of the facts concerning each belt and region in a neat and concise form.

Account for the characteristic conditions on the windward side of mountains in the belt of the Westerly Winds and for the contrasting conditions on the leeward side of the same mountains.

Account for the differences in climate and productions on the east and west coasts of continents in the Westerly Wind Belt.

*Name*________________________________

*Address*______________________________

Exercise XXXI.

THE OCEAN.

Material. Cross section paper, text book giving data concerning relative extent of land and water surface and data concerning relative height of land and depth of ocean.

(*1*) To represent diagramatically the relative extent of land and water surface of the earth.

From your text or reference books find out, as accurately as possible, the percentage of the earth's surface which is land and the percentage which is water. Allow one of the cubic centimeter spaces to represent one per cent. Outline one hundred spaces. Shade sufficient spaces to represent the land surface with a heavy shading and those representing the water surface with a light shading.

(*2*) To represent diagramatically the relative height of land and depth of water.

From your text or reference books find out the height of the loftiest peak of land and the average height of land. Also find the greatest depth of ocean and the average depth of the ocean. Draw a straight line across a page of cross-section paper. Allow the space between the light lines, up and down, to represent 1000 feet. At the left of the paper place a dot at the proper place above the line to represent the highest point of land. At one quarter of the way across the page place another dot to represent the average height of land. At three-quarters across the page make a dot below the line to represent the average depth of the ocean. At the right side of the page make a dot to represent the deepest measured water. Connect these dots with a curvd line and note on the diagram what each part represents.

Name—————————————

Address—————————————

Exercise XXXII.

OCEAN CURRENTS.

Material. A map showing the direction of the planetary winds, an outline map of the world on Mercator's projection.

(*1*) To determine the location and direction of the ocean currents by considering their cause.

On an outline map of the world show the direction of the prevailing winds off the following coasts by placing one or two lightly drawn arrows in the places indicated: Off the western coast of Spain. Off the northwestern coast of Africa. Off the southwestern coast of Africa. Off the southeastern coast of South America. Off the New England and New Foundland coasts. Off the southern point of Greenland. If the arrows represent the prevailing winds they must also show the direction the surface water will be blown at these places. Represent the surface currents of water as you reason they should go in the north Atlantic and in the south Atlantic ocean. Compare your deductions with the ocean-current chart in your text. Explain why these should be warm currents of water.

In the same way represent the prevailing wind directions off the following coasts in the Pacific ocean: Off the southwest coast of Mexico and Central America. Off the east coast of New Guinea. Off the coast of Japan. Off the west coast of South America at about 20° S. Off the west coast of New Zealand. Represent the ocean currents of the north Pacific and of the south Pacific ocean. Determine the direction and represent the currents of the Indian ocean.

Represent the wind direction in the Antarctic ocean. Show the ocean currents of the Antarctic. What will be the temperature of these Antarctic currents? Give the reasons why there should be a cold current running along the southwest coast of South America (Chili). Represent and account for the cold currents which enter the Atlantic and Pacific oceans from the Arctic ocean.

Name——————————————————

Address——————————————————

Exercise XXXIII.

A STUDY OF MINERALS.

Material. A few common minerals, each one labeled with its name, a small vial of dilute hydro-chloric acid and glass drop-rod, a small piece of glass, a knitting needle or steel scratcher. A magnifying glass.

(*1*) To become acquainted with the distinguishing characteristics of a few common minerals.

Study each specimen according to the following outline and make a concise, tabulated report on each specimen.

1. Name.
2. Color, and whether uniform or variegated.
3. Transparent, translucent or opaque.
4. Crystalline, semi-crystalline or amorphous.
5. If the specimen is a crystal give the shape of the crystal, number of faces, relative size of faces.
6. Fracture: Whether splitting in cleavage planes or shelly fracture.
7. Hardness: Will it scratch glass, will it show a scratch with steel, with the thumb nail?
8. Acid test: Effervesence or not.
9. Give any other characteristics of the mineral you notice.
10. Of what use is the mineral?
11. Give your reasons, from what you have observed of the mineral, for thinking it durable or weak.
12. What agent of erosion will have the greatest destructive effect?

Name————————————————

Address————————————————

Exercise XXXIV.

A STUDY OF ROCKS.

Material. A number of common rocks, each labeled with its name and all separated into their respective classes. A collection of unnamed but numbered specimens of rocks and minerals for identification. A small vial of dilute hydrochloric acid and drop-rod. A piece of glass. A knitting needle or steel scratcher. A magnifying glass.

(*1*) To become acquainted with the distinguishing characteristics of a few common rocks.

Study each specimen according to the following outline and make a concise, tabulated report on each specimen:

Igneous Rocks.

1. Name.
2. Color.
3. Describe each mineral composing the specimen as to its color, fracture, hardness, effect of acid, name.
4. Relative quantity of each mineral in the rock.
5. Relative size of the crystals of each mineral.
6. Durability of the specimen, whether solid, pliable or easily rubbing off.
7. Other noticeable characteristics of the rock.
8. Uses of the rock.

Sedimentary Rocks.

1. Name.
2. Color.
3. Does the specimen show stratification? If so, describe it.
4. Is the specimen firm or friable? Will it make a good building stone?
5. Acid test: Effervesence or not.
6. Describe the structure under the following heads: Size of grains composing the rock. Colors of different grains. Hardness of grains. How grains are cemented together. Color of the cement. Names of minerals composing the grains.
7. Does the specimen show any organic remains?
8. Other noticeable characteristics.
9. Describe conditions under which it seems to have been formed.
10. Uses to which the rock is put.

Metamorphic Rocks.

1. Name.
2. General color and distribution of color: solid, banded, mottled or irregular.
3. Crystalline, semi-crystalline or granular.
4. Size of crystals or grains.
5. What kind of fracture do the broken surfaces of the composing parts show?
6. Hardness: scratch glass, scratched by iron or thumb-nail.
7. Acid test: effervescence or not.
8. Other observed characteristics.
9. Was the specimen apparently metamorphosed from igneous or sedimentary rock? From what rock?
10. Uses to which the rock is put.

(*2*) To identify common rock and mineral specimens.

Identify each specimen by following the outline. Make a concise tabulated report on each specimen.

1. Number of specimen.
2. Class: Mineral, igneous, sedimentary or metamorphic.
3. Substances composing the specimen.
4. Distinguishing characteristics which indicate its variety.
5. Name of the specimen.

Name——————————————

Address——————————————

Exercise XXXV.

A STUDY OF SOILS.

Material. Labeled samples of the following soils: Clay, sand, sand loam, clay loam, humus soil, and others, if common in locality. Glass plate. Small vial of hydrochloric acid and drop-rod. Test tubes. Simple microscope. Two percolators made of a 5-inch piece of ½-inch glass tubing fitted at one end with a rubber or cork stopper having two small holes and a thin layer of cotton laid in above the stopper. Evaporating dishes.

(*1*) To become acquainted with the distinguishing characteristics of the common soils.

Examine each of the specimens of soil and write a report on each after the following outline.

a General color of the soil.

b Shake gently about a teaspoonful of soil in a large test-tube two-thirds full of water, till the material is thoroughly suspended; then let it settle. Note carefully what part settles first and what part last. Does the soil thus separate into widely differing grades or have the grades the same general appearance? Describe each grade.

c Spread a small portion of the dry soil on a glass plate. Examine it closely with a magnifier. Can you distinguish the grains of the different grades which were separate in *b*? Describe the appearance of each grade of grains, giving color, and wherever possible, shape of grains and kinds of minerals. By applying a drop of acid to a pinch of the soil something of its nature may be determined.

(*2*) To determine the porosity of soils.

Fill a percolator, to the depth of about three inches, one with each sample of soil. Hold a finger over the stopper holes and press the soil until it is compact in the tube. Arrange the percolator so it will have its lower end immersed in water to half an inch above the cork. Watch the water soak up through the soil. Does the water rise through the soil slowly or rapidly? In this way compare the porosity of the soils.

(*3*) To determine the solubility of soils.

Suspend each percolator above an evaporating dish and slowly pour into the tube enough water to fill the evaporating dish. Let the percolator stand until the water has percolated through the soil and filled the dish. What is the appearance of the drain water? Slowly evaporate the drain water from the dish. What is the nature of the sediment left? By comparing the amount of sediment thus obtained from the different soils an approximate comparison of the solubility of the soils may be had. Of what use to vegetation is the soluble part of the soil? What is the effect of rain on the soluble parts of the soil? Will the top soil be richer before or after a rain?

Name———————————————

Address———————————————

Exercise XXXVI.

INTRODUCTION TO STUDY OF CONTOUR LINES.

Material. A small modeling board about one foot square, soft clay, a foot rule, a pointed stick about one foot long, a sheet of cross-section paper.

(*1*) To model an island and map it with a contour map.

Let the board represent the water level. Out of the clay build up a mountainous island which you have seen or can imagine. The island should be about six inches wide, nine inches long, and five inches high. Make the surface of the island as irregular as you would imagine it to be. Suppose the island built to the horizontal scale of one inch to the mile and the vertical scale of one hundred feet to the inch, give the dimensions of your island. To measure the height of the island stand the foot rule vertically on the water level and place the pointed stick at right angles to the rule, so that it measures the height of the island. Mark off, on the island, lines which will show the hundred-foot levels in the following manner: Place the rule as you did in measuring the height. Place the pointer at the height of one inch on the rule and hold it firmly so that the point touches the model. Shove the rule around the island so that the pointer makes a slight scratch in the clay, an inch high, all around the model. Repeat the operation to mark the 200-foot line, the 300-foot line, etc. Turn the model up so that it may be viewed from the top and note how the lines approach and fall away from each other. Where the surface slope is gradual do the lines appear near together or far apart? Place the model in a convenient position and on a sheet of cross-section paper draw a contour map of the island to the horizontal scale of one centimeter equaling one mile. First measure several diameters of the island on the paper and then by free-hand draw the outline of the island. Estimate the distances between the hundred-foot contours and draw them inside of the outline.

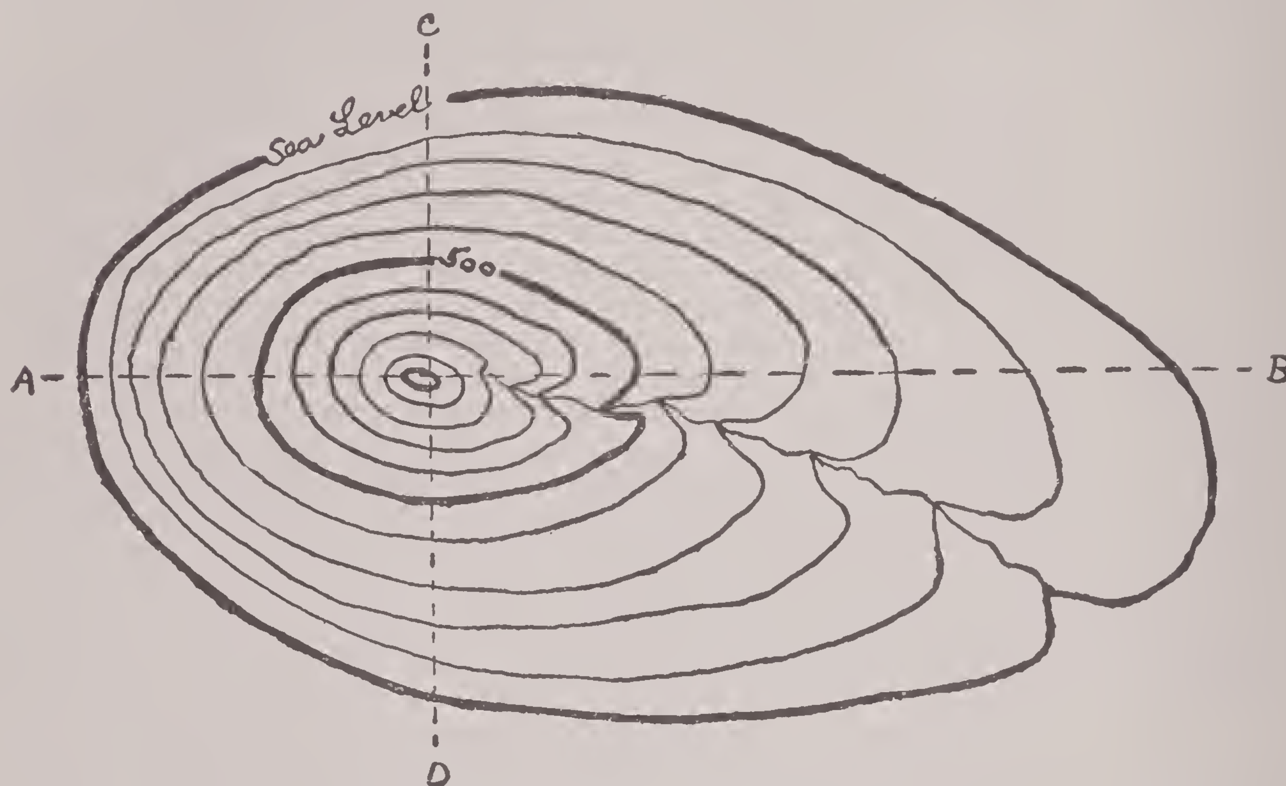
Name——————————————

Address——————————————

Exercise XXXVII.

ELEMENTARY CONTOUR EXERCISE.

Material. A sheet of cross-section paper, a foot rule.



Scale: One inch equals one mile.

(*1*) To comprehend a simple contour map and draw its profile.
The above drawing is a contour map of an imaginary mountain island in the ocean, with a stream on one side.

a What is the contour interval? What is the number of contour lines? What is the height of the top of the island above sea level?

b What does the number 500 denote? What lines are heavier than others, and why?

c How many light contour lines between two heavy ones? How many spaces? How many feet? In determining altitude do we count lines or spaces?

d Where the contours are far apart, what kind of slope is indicated? Where close together? With ruler and pencil draw a line from the top of the island to the shore down the steepest slope. Also a line down the gentlest slope.

e What is the scale of miles? How many miles long is the island? How many miles wide?

f Notice that the contours bend up stream where crossing the river. Do they bend uphill? What do these bends indicate?

g Draw a profile of the island along the dotted line AB, making the horizontal scale the same as the scale of the map. Make the vertical scale equal 1 cm. to 500 feet.

Note: Suggestions for making profiles from contour maps: Place a strip of paper along the line chosen for the profile. Make marks on the strip corresponding to the contours and write the values below the marks. Lay the strip on a sheet of cross-section paper along a line which should be marked sea level or some other convenient base level. Above each mark on the strip make a dot on the cross-section paper at the proper height, depending on the vertical scale, and connect the dots by a line which will be the profile.

Name——————————————

Address——————————————

Exercise XXXVIII.

A STUDY OF RIVER ACTION.

Material. Moulding sand, some small stones, soft clay.

To demonstrate the formation and aging of a river.

Take a large mass of moulding sand and build up a hill on top of the trough or sink. Make the hill to be fully ten inches high at the back and slope gradually toward the front over a distance of at least two feet. Pack the sand down hard and imbed some rock or layers of clay in the surface of the hill; then put on another layer of sand. Do not pack this upper layer or smooth off the surface of the hill, but leave it with rolling hollows, to have the natural appearance of a long land slope.

(*1*) Turn a very light spray of water over the surface of the hill with the sprinkler, to imitate a gentle rain storm, until all of the hollows form small lakes. Make a drawing of the slope containing the lakes.

(*2*) Turn the spray onto the extreme back of the hill and allow a small stream to cut its way down the slope, through the lakes, to the front of the hills and flow off into the trough beneath. Notice carefully the work done by the miniature river and make drawings and write explanations of the various features. The following should be found:

a The formation of a bed. What conditions determine the course of the river? In what part of the stream does it cut with the greatest force? How does it form a canyon? Describe a consequent stream.

b Cutting down of lakes. What becomes of the lakes? Where does the river cut out the lake shore to drain it? What is left where the lake stood?

c Falls. Where are the falls formed? What relation do the falls bear to the old lake bed? How do the harder layers of sand or clay or rocks aid in forming falls?

d Flood plain. What is the water doing with the soil it carries off the hill into the sink? Make the stream of water much smaller for a while, what is left where the water formerly flowed? Make a drawing of the flood plain.

e River sand bars. Place a small stone in the stream of water back in the sink. Where does it make the water flow slower, up or down stream from it? On which side of it will the sediment deposit? Make a drawing of the sand bar.

f Delta. Dam up the exit and make a pool of still deep water. Increase the flow of your water at the source of the stream and notice the deposition of sediment in the deep water until it comes to the water line. Decrease the flow of water and make a drawing of the delta and show how it was formed.

Name——————————————————

Address——————————————————

Exercise XXXIX.

A STUDY OF RIVER DEVELOPMENT.

Material. The Ottawa, Ill., sheet of the U. S. G. S. A relief map of the United States.

(*1*) To comprehend the characteristics of a Young Region.

This area represents a young country about as the continental ice-sheet left it, except that the streams have done some erosion since the glacial period. The Illinois river, during the closing years of the glacial period, was a large river, filling the entire valley shown on the map, and draining Lake Chicago, the ancestor of Lake Michigan.

a Give the contour interval and the scale of the map.

b What part of a square degree does this map represent? How many square miles? Indicate the location of this region on the relief map.

The Region.

c Find a hill top. How do you recognize it? Give its location by latitude and longitude, and by giving the number of miles and its direction from Ottawa. Give the length, breadth and altitude of the hill.

d The Prairie. Where is the largest level area on the map? Give its altitude. In what direction and how many miles could you go on it without changing your altitude more than ten feet? Standing in the middle of this level area could you see Ottawa? Are the wagon roads on it straight or crooked? In what direction do the main roads extend? Why?

The Valleys.

e This entire area once had a topography almost like that of the prairie; observe how the surface has been changed by the rivers. About how wide is the Illinois River Valley? How many feet deep? The average slope here is nine inches per mile. Compare the Fox River Valley with the Illinois in width, depth and slope. Get the slope by dividing the contour interval by the number of miles between two consecutive contour lines crossing the river. How does a valley change in width, depth and slope as it gets older? In what part of Buck Creek is the slope steepest? In what part is the valley deepest? How does Covet Creek differ from Buck Creek in the position of its steep slope, in the length of the deeper part of its valley, and in the frequency of its tributaries? Which is older? Is there room for the small streams to increase much in length? Do the tributary valleys begin to develop at the main valley or back on the divide? Why? Do they generally meet the larger valleys at a high or a low angle? Why?

The Divides.

f Describe the divide between Buck Creek and the Illinois River. Give the height of the divide above each stream. Is it broad or narrow, level or hilly? In what way will the divide change as the valleys get older?

Make a profile across the Illinois River Valley, along a line drawn on the map by the teacher, having the horizontal scale the same as the map; and a vertical scale of 1 cm. to 100 ft.

When the Illinois River was the outlet of Lake Chicago its volume of water was much larger. At that time was its valley developing more or less rapidly than it is at present? Was it able to carry more or less sediment than now? What became of the sediment when the stream decreased in volume? How deep has the terrace thus formed been cut by the present river?

Culture.

g What topographic conditions determine the location of Ottawa? Could either the Fox or the Illinois rivers be used for water power? Why does the Rock Island Railroad follow the river? Why does not the Burlington go straight south from Ottawa? Explain how it climbs out of the Fox River Val-

ley at the north. The Illinois and Michigan Canal crosses the Fox River in an aqueduct. About how high above the river is the aqueduct? How is water obtained from the Fox River to "feed" the canal? Where are the wagon roads irregular? Why there? Are there any running parallel with the Illinois River on the top of the bluff near the edge? Give the reason.

In what particular is the prairie adapted to the occupation of its inhabitants?

Name——————————————

Address——————————————

Exercise XL.

A STUDY OF RIVER DEVELOPMENT.

Material. The Charleston, W. Va., sheet of the U. S. G. S. The same relief map of the United States used in Exercise XXXIX.

(*1*) To comprehend the characteristics of a Mature Region.

The area shown on this map is part of an extensive plateau reaching from New York to Alabama along the western border of the Appalachian Mountains. This plateau is known in the northern portion as the Catskill Mountains, in the intermediate portion as the Allegheny Plateau, and in the southern portion as the Cumberland Plateau.

a Give the area covered by this map in square degrees and in square miles. What is the contour interval? Indicate the location of this area on the relief map.

THE REGION.

b Is the region level or hilly? How is this shown by the contour lines? By the roads and railroads?

c What is the altitude of Kanawha River at Lock 4 and at Lock 7? What is the direction of flow? What is the fall per mile? Is it a swift or slow stream?

THE RIVER VALLEY.

d Give the depth of the valley at Lock 5. What is the width of the flood plain as compared with the width of the stream? What does this indicate as to the age of the river?

e Note the bends in Kanawha River. Were they formed before or after the valley was made? How is this shown? What does this indicate as to the age of this region?

f What do the following show as to age of this region as compared with the Ottawa region? Number of tributaries? Angle of tributaries with main stream? General topography?

THE DIVIDES.

g Obtain the height of the divides in different places in the southern portion of the sheet; then in several places in the northern portion. How do the divides in these areas compare with each other in height? The strata which compose the hills are horizontal. How were the hills made? Which was the earlier topography (level or hilly) and toward what direction was the slope?

h Observe the curves in Coal River. Were they formed before or after Coal River cut its valley? How do you know? What do they show as to the earlier topography?

CULTURE.

i Does the number of constant streams indicate a light or heavy rainfall? Among the strata of the hills are beds of coal. Why can it be easily mined here?

j Give the reasons for the location of Charleston. Find and name other similarly located towns and villages. Explain the location of roads and railroads.

Name——————————————————

Address————————————————

Exercise XLI.

A STUDY OF RIVER DEVELOPMENT.

Material. The Caldwell, Kansas, sheet of the U. S. G. S. The same relief map of the United States used in Exercise XL. Also the Ottawa and Charleston sheets for reference.

(*1*) To comprehend the characteristics of an Old Region.

a Give the contour interval and the scale of this map.

b Give the area of the region represented by this map in square degrees and in square miles. Indicate the location of this region on the relief map.

THE REGION.

c Is the region level or hilly? How is this shown by the contour lines? Compare the contour lines of this map with those on the Ottawa and Charleston sheets. Which does the Caldwell sheet resemble more? Are the wagon roads and railroads confined to the valleys as in the region of Charleston? Give a reason for this. Are the railroads as straight as in the Ottawa region? Give a reason for this.

THE VALLEYS.

d Compare the number of streams with the number in the Charleston area. What explanation can you give for this? Find some streams which are intermittent. What part of the stream is intermittent? Why at that particular place? Is the rainfall heavy or light?

e In what direction do the streams flow? What is the difference in the altitude of the Chikaskia River at the western and the eastern borders of the map?

f Compare the slopes of the valleys of even the smallest streams in the Caldwell area with those in the Ottawa and Charleston areas. In which of the three areas do the valleys show the most advanced age?

THE DIVIDES.

f Is the general shape of the divides broad or sharp in the Caldwell area? What is their form in the Ottawa area and in the Charleston area? Taken in connection with the shape of the stream valleys, what indication of the age of the region does this give and why?

g Follow the course of the Chikaskia River across the map, looking for the evidences of falls and rapids. What is your conclusion as to the age of this region? Give the other evidences of age which are to be found in the (1) angle at which the tributaries join the main stream; (2) prevalence of lakes and swamps.

CULTURE.

h To what occupation is this region suited?

(*2*) To compare and describe the development of a region.

By comparing the topographical characteristics of the Ottawa, the Charleston and the Caldwell regions write a description of the successive stages of youth, maturity and old age through which a region passes which was formerly level and moderately elevated above the sea. The description should compare (1) general appearance of each region, (2) the valleys, (3) the divides, and (4) the culture of each region.

Name——————————————

Address——————————————

Exercise XLII.

A STUDY OF THE MISSISSIPPI RIVER.

Material. The Savanna, Iowa-Illinois sheet and the Donaldsonville, La., sheet of the U. S. G. S. Mississippi River sheet No. 14 of the Mississippi River Survey. The relief map of the United States used in the previous map study. Cross-section paper.

(*1*) To study a typical river combining the essential characteristics of all rivers.

A. Savanna (Iowa-Illinois) sheet.

This sheet represents a portion of the Upper Mississippi River and the adjoining region directly west of Chicago. It lies almost wholly within the Driftless Area, but the present drainage is quite different from that which existed in this region before the Glacial Period. The out-washings from the glacial moraines filled the valley of the Mississippi River with sand and gravel to a depth of 150 feet. The lower courses of tributary streams were also filled to a corresponding depth. The upland is covered to a depth of 10 to 20 feet with a deposit of fine soil called loess. Underneath this soil is a bed of limestone.

THE REGION.

a Indicate the location of this region on the relief map of the United States. Give its area in square degrees; in square miles. Give the scale and the contour interval of this map.

b What does the broken line in the river denote? What length of the river is shown on the sheet. (Measure along the broken line.) Give the average width of the river. (Measure where all the water flows through one channel.)

THE VALLEY.

c Give the greatest and least width of the flood plain. Give evidences that the river is still widening its valley. Have the valley sides steep or gentle slopes where the river approaches them? How do the contours show this? How can you tell that the river is not cutting down into its flood plain to any extent?

d What evidences are there that the river is usually overburdened with sediment? Explain the presence of the short, wide flood plain tributaries three or four miles south of Savanna. What evidences do you see of a former channel along the eastern side of the flood plain below Savanna? Where do you see oxbow lakes, and of what streams were they probably once a part?

e How much of a rise in the river would inundate Sabula? What becomes of the water flowing down Rush Creek? What is the altitude of the base of the bluffs as shown by the heavy contour running along them? What is the altitude of the heavy contour at the top of the bluffs? How high are the bluffs along the river here? What two tributaries have cut broad trenches through the bluffs on the east? What will gradually become of the bluffs?

THE DIVIDES.

f Do the contours on the upland run straight or crooked? Does this fact denote a rough or a smooth country? Have the main divides been much roughened by erosion, or are they nearly smooth? Are they narrow or broad? Will they become broader or narrower? Why?

CULTURE.

g Do the main wagon roads follow the valleys or the divides? Why? In what stage of development will they be transferred?

h Before the Glacial Period the upper part of Plum River flowed southeastward and the lower part flowed along the present course. How does the development of the present valley show where the old divide was located?

i Make a profile across the Mississippi River Valley along the line A-B, making the vertical scale 1 cm. to 100 ft. and keeping horizontal scale the same as the sheet.

B. Donaldsonville (La.) Sheet.

This sheet represents a portion of the Mississippi River and adjoining flood plain in the lower part of its course. Natural levees have been formed along the river. Donaldsonville is 185 miles from the mouth of the river and 75 miles above New Orleans.

THE REGION.

a Indicate this portion of the river on the relief map of the United States. Give the scale and the coutour interval of this sheet. Does the use of a small contour interval denote a steep, a moderate or a gentle slope? Name the points at the most prominent bends in the river.

THE VALLEY.

b How wide is the river between Port Barrow and Darrowville?

c Within how many feet of sea level is the swamp flood-plain south of the river. On the east side of the sheet? Has the northeast swamp a greater or a less slope than the natural levee along the river? How is this shown? Can swamp land have a steep slope? Why?

d Make a sketch of the river where it bends around Brilliant Point and draw a dotted line showing the position of the main current in the channel. From this sketch what reason can you give for the outbreak of Nita Crevasse? Why do the 10 and 15 foot contours curve toward the river as they pass the crevasse? Account for the alluvial deposit east of the crevasse.

e Does the slope of the natural levee increase or decrease as one approaches the river from the swamp? Give a reason for this? Where is the farm land of this region situated?

CULTURE.

f What is the plan of the wagon roads? What determines the plan? On what roads are the most buildings located? Why? What direction do the small streams have relative to the river? Account for this.

g The straight blue lines are ditches. Why are they necessary? Where do they carry the water?

h Is the natural levee composed of fine or coarse material? Give a reason for this. What is the width of the natural levees including the river along the line A-B?

i Make a profile across the levees and river along the line A-B; having the same horizontal scale as the map, and the vertical scale 1 cm. to 25 ft. Make a profile having a vertical scale of 1 cm. to 100 ft. to compare with the Savanna profile.

C. Mississippi River Sheet, No. 14.

This sheet represents a meandering portion of the Mississippi River in the Lower Alluvial Valley about 650 miles from the mouth. The distance below Cairo, the mouth of the Ohio river, is marked every 5 miles by figures in midstream.

a Indicate this portion of the river on the relief map of the United States.

b How many miles from Jones' Landing to Sunnyside Landing? (Use a midstream distance.) What is the river distance between Offutt's Landing and Sunnyside Landing? What is the straight distance between the same two landings? (Compare with the river distance.)

c Why was it necessary to survey the river again after 12 years? Does the current line follow the outside or the inside of a bend? Why? On which side of a bend does the river cut into its bank? Why? In what part of a bend are bank bars usually formed? Why? Tell how Miller's Bend furnishes examples proving the truth of your last three answers.

d How far did the bank at Georgetown Bend wear back during the 12 years between the two surveys? How much farther must the bank here be worn away to cut through the remaining neck of land? At the same rate of cutting when

would the cut-off be formed? How many miles would the river be shortened by this cut-off?

e What part of the width of the old channel at Rowdy Bend is filled by the more recent sand bar? How far back has Barnes' Landing (a mile above Greenville) been moved? What now occupies the old channel at this place?

f What has the river already done to Greenville? What may happen in time? How may it be prevented?

g Make a sketch of a short portion of the river at Walker's Bend as it was when Lake Chicot formed part of the channel. How did Lake Lee originate?

Name————————————————

Address————————————————

Exercise XLIII.

THE CONTINENTAL ICE SHEET OF NORTH AMERICA.

Material. A map showing the centers and extent of the ice sheet. (See text.) A relief map of North America.

(*1*) To represent the centers of origin and the extent of the continental ice sheet.

On the relief map of North America mark the location of the following centers of origin by placing the name over the locality.

1. The Labrador center just south of the Labrador Highlands, midway between Newfoundland and the east shore of Hudson Bay.

2. The Keewatin center just west of the most westerly shore line of Hudson Bay.

3. The Pacific center just east of the Cascade mountain range opposite Queen Charlotte Island.

By referring to the map of the ice sheet indicate carefully the exact location of the most southern extent of the ice sheet by a heavy line.

Indicate the direction of the flow of ice by starting at each center and drawing light dashes away from the center in every direction. These should show that the ice from the Labrador and the Keewatin centers met over Hudson Bay and farther south over Lake Superior. From which center was New England covered? From which center was Illinois and Michigan covered? From which center was Wisconsin and Minnesota covered?

Indicate the driftless area of Wisconsin which the ice did not cover.

What effect did the ice sheet have upon the old mountain ranges of New England? What effect did the ice sheet have upon the mountains of Canada? Where did the ice sheet drop its load of soil? Account for the rich soil over the agricultural regions of the upper Mississippi Basin. Account for the numerous lakes in northwestern Canada.

Name——————————————

Address——————————————

Exercise XLIV.

A STUDY OF GLACIAL TOPOGRAPHY—I.

Material. The Whitewater, Wisconsin, sheet of the U. S. G. S. The relief map of the United States used in Exercise XLII.

(*1*) To comprehend the characteristics of a recent glaciated region.

This sheet represents a part of the area covered in the latest glacial epoch. The slopes are usually not too steep for cultivation. Indicate the location of this sheet on the relief map of the United States and upon the glacial map of Exercise XLIII.

A. The moraine covers the southeast third of the map. It is a portion of the "Kettle Moraine" left between two great lobes of the ice sheet, the Green Bay and the Michigan lobes.

a Locate this moraine on a large map and name the towns on or near it.

b What is its trend or direction of its length and its width on this sheet? (Measure across to the swamp in the southeast corner.)

c How high are the hill tops above the sea? Above the marshes? Describe the shape of the hills. Are the hill tops broad or sharp? Are the hollows regular or irregular? (Marked by depression contours.) What are their depths? Are they always occupied by water? Are they filled to overflowing, *i. e.,* have they outlets? Were they produced by stream erosion? Give reasons for your answer.

B. The drumlins are found in the northwest part of this region and were formed under the Green Bay lobe of the ice sheet.

a Give their altitudes above the sea and above the marsh. Give the width and the length at the base of two or three of the most prominent. Are they broad or sharp topped? What is their trend? Compare with the trend of the moraine and with the direction of movement of the glacier. About how many drumlins are there in the 25 square miles south and west of Rome?

C. General topography.

a Do any streams flow completely across the moraine?

b What evidence of erosion is there just south of Whitewater? At what other places is erosion noticeable?

c Do the streams in the marshes erode much? Why? Is there any regularity in the distribution of marshes and lakes? Are they regular or irregular in shape? What will be their fate? Point out any that have clearly progressed toward this end. Indicate some marshes that could be artificially drained for agriculture.

CULTURE.

a Where are the roads greatly influenced by the topography? Where little? Do the wagon roads follow the high or the low lands? The railroads? Why this difference?

b What topographic reasons are there for the location of the villages here shown?

(A good-sized, dry, fairly level area lies just west of Whitewater.)

Name——————————————————

Address——————————————————

Exercise XLV.

A STUDY OF GLACIAL TOPOGRAPHY—II.

Material. The St. Paul, Minnesota. Sheet of the U. S. G. S. The relief map of the United States used in the previous exercise.

(*1*) To comprehend the effect of glaciation upon the development of rivers. This sheet represents a glaciated region in eastern Minnesota. It has been twice glaciated. The first glaciation was due to ice moving in from the east. This compelled the Mississippi River to move westward, where it made a gorge for itself west of Minneapolis. During the second glacial movement the ice came in from the west and northwest. This drove the river eastward, when it chose its present course. When the ice left, the river began to cut the gorge which extends from Ft. Snelling to the Falls of St. Anthony. The Minnesota River and the Mississippi River below the gorge occupy the old channel of the River Warren, which was the outlet of the glacial Lake Agassiz.

THE REGION.

a Locate this area on the relief map of the United States. What is the contour interval and the scale in this sheet? Give the area of this sheet in square degrees and in square miles.

THE VALLEYS.

b Make a cross section of the gorge of the Mississippi and of the Minnesota. Make the first section one-half mile above the line marked 55′ and parallel with it. Make the second section to cut the second "e" in "Hennepin" and the "o" in "Dakota," and have it extend one mile back from the flood plain on either side. Compare the two cross sections. What is the width and depth of each? What is the height and slope of the bluffs? What is the width of each as compared with the width of its flood plain?

c Give the fall in feet of the Mississippi River from the Falls of St. Anthony to the mouth of the gorge. Give the fall of the Minnesota River from the point where it enters the sheet to Pike Island.

d Describe the divide between the Minnesota River and the gorge of the Mississippi River. Is it high or low above stream? Is it level or hilly? Is it broad or narrow? Will it ever change? Why? Which is the older, the Mississippi River or the Minnesota River at this place? Give your reason in full.

e Notice the bench or terrace which appears on the east side of the Minnesota River at a height of about 780 feet above the sea. This is what remains of a mass of river-brought sediment, *i. e.,* gravels, sand and silt, deposited in a pre-glacial gorge by waters coming from the melting ice. The gorge was filled throughout its length to the level of this terrace. The River Warren, which was the outlet of Lake Agassiz, cut into this material, thus forming the terrace. When the lake found an outlet to the north, the volume of water in the river was greatly reduced. It cannot now remove all the materials brought by its tributaries. During flood time the river spreads much of this material over its flood plain. What is the height of this terrace above the flood plain? What is its width? Find other terraces either along the Mississippi River or the Minnesota River. Locate them and give their height above the flood plain; also their length and width. Would the reasons given for the existence of the first terrace explain the others?

RIVER ACTION.

What is its slope in feet per mile? Is its velocity great or little? Can it transport much or little material? How is its velocity affected when it reaches the flood plain? What becomes of the stream? What becomes of the material it carried? In flood time the Mississippi covers the marshes. How will the material brought down by the tributaries be affected?

g Underneath the drift of the region is the hard Trenton limestone, and below this is the soft St. Peter's sandstone. It is due to this hard capping that the walls of the Mississippi River keep their steep slope. Locate the Falls of Minnehaha. What is its height? What keeps it a fall? Is the fall stationary or still cutting back? What will become of it if the water continues to flow over it?

h What map previously studied had a moraine like that in Egab Township? Name the moraine. What maps showed are like that in Ramsey County? Compare the surface of Egab Township with an equal area on the Charleston Sheet. In which is the drainage better developed? Give your reasons.

CULTURE.

i What is the reason that Minneapolis was located where it is? Account for St. Paul's location. (The river is navigable to St. Anthony's Falls.)

Name——————————————————

Address——————————————————

Exercise. XLVI.

A STUDY OF GLACIATED AND WATER-WASHED PEBBLES.

Material. A number of pebbles taken from undisturbed glacial drift. A number of assorted pebbles taken from a lake beach or river bed. A knitting needle or steel scratcher. A vial of hydrochloric acid and drop-rod.

(*1*) To be able to distinguish whether a region has been more recently glaciated or water-covered by the appearance of the surface pebbles.

A. Glacial Pebbles. These pebbles were broken by the glacier from ledges of rock usually but little weathered.

a Is there any uniformity in their size or form?

b Of what kinds of rock are the pebbles composed? What does their composition suggest about the localities from which the pebbles came?

c What kind of rock predominates? What relation has this fact to the kind of rock underlying the region where the pebbles were collected?

d In what ways did the glacier affect the surface of the pebbles? How differently are the stones of different hardness affected? Do you find more than one surface on any of the pebbles planed? Explain how this could be done. Are the striae on a surface all parallel? Why?

e How do you explain the fact that some pebbles are sharp angled and irregular, while others are completely smoothed? What variety is usually angular?

f In a specimen which has been broken in two, do you find the interior differing from the outside in color or hardness? What does this denote as to weathering?

B. Water-washed Pebbles. These pebbles were washed about by the water and considerably eroded by waves or currents.

a Do these pebbles show the planed surfaces and the striae made by the glacier? Give the reason.

b Do you find these pebbles differing in kind from those in the glacial collection? What kinds are there?

c Did the water wear these pebbles by sliding them or rolling them? Do some of them show one sort of movement and the others another movement? The pebbles are approximately what shapes or tending toward what general shapes? What are the causes for each shape?

d If you see any differences in the effect of the water's work on the different kinds of rock, state what it is and explain why it is. Explain the reason for depressions, projections, etc., found prominent on the surface of the pebbles.

e In specimens broken in two, how does the interior differ from the exterior in color, hardness, etc.? To what depth has the weathering penetrated? Compare with the glacial pebbles in this respect.

Name———————————————

Address———————————————

Exercise XLVII.

A STUDY OF SHORE LINES—I.

Material. The Atlantic City, New Jersey Sheet of the U. S. G. S. The relief map of the United States used in the previous exercises for locating the regions. Cross-section paper.

(*1*) To comprehend the characteristics of an old, worn coast.

This sheet represents a portion of a gently sloping sandy plain meeting the open sea.

a Give the scale and contour interval of this map. Give the area in square degrees and in square miles of the area represented. Indicate the location of this region on the relief map of the United States.

b Give the name of each beach, its length, its average width and its altitude. How were the beaches formed? Where did the material come from? What distance are the beaches from the mainland? What fixed this distance? Is a large or a small portion of the beach more than 10 feet in altitude? How were the small hills (dunes) formed? Does the end of the beach generally hook toward or from the land? Why?

c Explain the presence of the inlets.

d Draw a line to represent the outer margin of Brigantine Beach; another to represent the inner margin. Give a reason for the difference.

e Is the boundary line between the mainland and the marsh fairly straight or very crooked? Why?

f Are the bays increasing or decreasing in depth and extent? By what means? What once occupied the space between the beach and the mainland? What will this area become in time?

g Could one go in a small boat from the northeast to the southwest part of the map through enclosed waterways? What is the significance of the word "thorofare"?

h Make a map of the marsh extending a mile and a half northwest from Atlantic City, to show the distribution and form of small tidal creeks.

i From the figures written on the map, indicating depth in feet, do you observe a perfectly uniform or a somewhat irregular slope of the sea bottom? Why does the channel into Great Bay come from the south instead of from straight east?

j Make a profile of the land and a cross-section of the water from Leeds Point east through New Inlet having the horizontal scale the same as the map and the vertical scale 1 cm. to 50 feet.

k If the coast should rise ten feet what difference would it make in the general appearance of the coast? Would new beaches result?

CULTURE.

l Why are there no commercial cities between Sandy Hook and Cape May? (See a large map.)

m Give two reasons for Atlantic City's being such a famous summer resort. Why did it grow up where it is rather than on one of the other beaches?

n How far apart are the life-saving stations Why is there need of so many here?

Name————————————————

Address————————————————

Exercise XLVIII.

A STUDY OF SHORE LINES—II.

Material. The Boothbay, Maine, Sheet of the U. S. G. S. The United States relief map used in the previous exercise.

(*1*) To comprehend the characteristics of a young coast.

The land is composed of hard, massive rock and a thin glacial detritus scattered unevenly over the surface.

a Give the scale and contour interval of this map. Give the area in square miles and in square degrees of the region represented. Indicate the location of this region on the relief map of the United States. What is the direction and distance of Boothbay from Portland?

b What is the most noticeable characteristic of the topography? Give the altitude of several of the large hills. Have they flat or pointed tops? Are the valleys narrow or wide? Give the trend of the hill ranges. The valleys extend in what direction? The glaciers moved in what direction? See Cushman Hill, Barter Island, and Big Hill for indications of the glacial movement.

c What is the general shape of the large islands? Their height? Compare with the hills of the mainland. What trend have the peninsulas and large islands? What is their position with reference to the hill ranges of the mainland? How were they produced?

d Make an outline of Big Hill peninsula (south of Boothbay village) and shade the portion that would be covered by water if the land should sink 100 feet. If Barter Island should sink 100 feet, how many islands would be formed from it? If the entire region should sink 100 feet, what would become of some of the low islands? Of some of the peninsulas?

e Why have the two large rivers on this sheet no perceptible slope?

f Describe the bays as to their form and depth with those of the Atlantic City region. How were they produced here?

g Why are marshes not extensive or abundant here? Why not beaches? Why is the coast line so irregular? Would the coast become more or less regular if it should sink 100 feet? What effect would it have upon its regularity if the coast should rise 100 feet?

CULTURE.

h Why is this coast more thickly settled than the New Jersey coast? Why are there not many life saving stations here? Why were ship building and fishing once the leading occupations? Is travel easier east and west, or north and south? Why? Explain the locations of villages.

i Make a cross section of the bay from Damiscove Island west; having the horizontal scale the same as on map and the vertical 5 fathoms 1 cm. Explain the shallow water near the middle.

Name————————————————

Address————————————————

Exercise XLIX.

A STUDY OF SHORE LINES—III.

Material. A relief map of the United States.

(*1*) To identify the coasts as young or old according to the prevailing characteristics.

Tell of each of the coasts along the Southeastern Coast of the United States, the California Coast, the New England Coast, whether it is a young or old coast and whether it has been recently rising or sinking,

Name————————————————

Address————————————————

Exercise L.

A STUDY OF A PLAIN.

Material. The Wicomico, Maryland—Virginia, Sheet of the U. S. G. S. The relief map of the United States used in previous exercises.

(*1*) To comprehend the topographic characteristics of a plain.

This sheet represents a portion of the Atlantic Coastal Plain within the area of submergence west of Chesapeake Bay. The soil is arranged in at least five well defined layers, showing as many submergences and corresponding re-elevations, and on the upland or divides is about 500 feet thick. It consists largely of clay, marl, Fuller's earth, sand and gravel. Underneath the soil is a floor of crystalline rock similar in formation to that of the Piedmont region farther west.

The Region.

a Locate this region on the relief map of the United States. What is the scale of the map? How many square miles does the sheet represent? What is its contour interval? Are the contours much crowded on the sheet? What does this indicate as to steepness of slope?

The Valleys and Marshes.

b Are the banks of the large rivers high or low? Within how many feet of sea level is the salt marsh everywhere, as shown by the contours? Why are salt marshes found so far up these rivers from the sea?

c How wide is Wicomico River? How long? Why is the width so great in proportion to the length? Has the river any perceptible slope? Why? Is the river being deepened or filled? Give the reason. The large valleys coming down from the north into the Wicomico River are not so deep as formerly. How were they filled? What accident prevents further deepening?

d Why are Zekiah, Gilbert and Chaptico swamps fresh and not salt marshes? What is the average width of Zekiah swamp? Gilbert swamp? What reason can you give for Gilbert swamp being so wide at one place? Where might a similar widening occur in Zekiah swamp? What has prevented this? About how far below the upland divides are these swamps? Did the same general accident affect the minor streams to any extent? Why? Where is much of the sediment which they carry deposited? What has resulted from this? Have these small streams developed much of a flood plain? Where? Why there? Can these streams get much longer? Why?

e Give length, total fall and slope per mile of Pope, Budd and Chaptico Creeks. Make a longitudinal profile of Budd Creek, following the upper western fork. (Follow the creek with the edge of the paper as you lay off the contours.) Make the horizontal scale the same as the sheet and the vertical scale 1 cm. to 100 ft. Where is the slope steep? Where gentle? Where is most vertical erosion being done? Where least? Why?

The Divides.

f Where does the Potomac River show high, steep banks or bluffs? How are the bluffs being destroyed? How far back from the river are the bluffs at Ludlow Ferry? Are these as steep as those near the river? Give a reason for the difference. How many main divides are shown on the sheet? About how high are they above sea level? Are they broad or narrow? Even or uneven? What change will they naturally undergo?

Culture.

g Are the wagon roads planned to follow divides or valleys? Why? When, if ever, will they be changed to the other position? What valleys already have roads? Why? Do the railroads here generally follow divides or valleys? Why? Why does the B. & P. R. R. follow Pope Creek Valley to Faulkner instead of taking a more direct route across the upland?

h Of what value, aside from farming, are the soil formations of this region?

i Judging from the past history of this region, what may one predict as to its future?

Name——————————————————

Address——————————————————

Exercise LI.

A STUDY OF A PLATEAU.

Material. The Kaibab, Arizona, Sheet of the U. S. G. S. The relief map of the United States used in the previous exercises. Moulding Sand.

(*1*) To comprehend the topographic characteristics of a plateau.

This sheet represents about 75 miles of the Grand Canyon of the Colorado River in the high plateau of northern Arizona. The most accessible trail down the canyon is on the southern side opposite the mouth of Bright Angel Creek.

THE REGION.

a What is the area of this sheet in square miles? In square degrees? Indicate the location of this region upon the relief map of the United States. What is the contour interval? What must be the character of the slope represented by such an interval? What is the scale on this sheet?

THE PLATEAUS.

b Name the four plateaus on the sheet and give the altitude of each by its highest thousandth contour. How far below Powell's Plateau is the Colorado River? How are the plateaus separated from each other? How will the plateaus become still more widely separated? How closely were they probably connected at one time?

c How wide at the top and how deep is the valley separating Powell's Plateau from the region eastward? Tell where the larger plateaus are being dissected.

THE VALLEYS.

d Considering the large area represented on this sheet, are there many or few streams? Many or few stream valleys? Why are so many of the valleys dry? What change in climate does this indicate? Why has the Colorado River such a deep valley here? What is the character of the valley as shown by the numerour contours running along so near to the river? If this region had a moist climate, how would the shape of the valleys differ from that represented on the sheet?

e Note that two gorges are shown, an inner and an outer. Where are both gorges well shown? What tributaries also show both? These gorges show that what kind of an accident has happened here during the life of the river?

f How wide is the Colorado Canyon just above the Cataract Creek Canyon? How deep is the canyon here? At what depth does the inner gorge begin? How deep is the inner gorge? Make a profile across the canyon at this same place, using the following data, with the horizontal scale four times that of the map and the vertical scale of 1 cm. to 1,000 ft.

Dist. from Starting Pt.	Alt.	Dist. from Starting Pt.	Alt.
.0 cm.	6250 ft.	8.8 cm.	River
1.8 "	6250 "	9.0 "	2000 ft.
2.8 "	5000 "	10.0 "	4000 "
7.0 "	4000 "	14.1 "	5000 "
7.4 "	3000 "	15.2 "	6250 "
8.1 "	2000 "	17.0 "	6250 "
8.2 "	River		

CULTURE.

g Why are the springs so carefully located on this sheet? Is this region better adapted for farming or stock raising? Why?

(*2*) To represent the characteristics of the plateau and canyon by a model.

Take about six pounds of moulding sand. Dampen the sand slightly. Mix the sand thoroughly and pulvarize it between the fingers until it is fine and soft and just damp enough to hold its form when pressed. Beginning with the region about Cataract Creek Canyon build up the sand on each side of the canyon until the plateau and canyon are well represented to show the relative depth and width of the canyon with its gorges.

Name————————————————

Address————————————————

Exercise LII.

A STUDY OF MOUNTAIN TOPOGRAPHY.

Material. The Harrisburg, Pennsylvania, Sheet of the U. S. G. S. The relief map of the United States used in the previous exercises. Moulding sand.

(*1*) To comprehend the topography of the Appalachian Mountains in this region. This sheet represents a portion of the Appalachian Ridges in southeastern Pennsylvania. The rock strata of this region, consisting of hard sandstones and conglomerates alternating with softer limestones and shales, were once bent into a synclinal fold and afterwards greatly eroded.

a Indicate the location of this region on the United States relief map. What is the scale of the map? How many square miles are represented on the sheet? What is its contour interval? Why could not a smaller interval be used on this sheet?

b What is the river distance between Half Falls and the 300 contour line above Harrisburg? What is the slope per mile? Why was a canal built along the river here? How long is the Pennsylvania Railroad bridge at Ft. Hunter?

c Harrisburg is situated on land that was probably once an island in the river. How does the sheet show this? What stream now occupies the east side of the former island? How many feet must the river rise to make Harrisburg an island town? In what respect does Haldeman Island resemble the former conditions at Harrisburg? Under what conditions will Haldeman Island become a part of the mainland? How high is Haldeman Island above the river? How high above the river is the State Capitol at Harrisburg? Also the State Lunatic Asylum north of Harrisburg?

d Name the four prominent ridges east of the river and give the direction of trend and the altitude of each by its highest hundred contour line. About how far are the tops of the ridges apart? How far is it from the top of Peters Mountain to the top of Blue Mountain? What kind of rocks compose the ridges? The valleys? (See the introduction.) Give your reason for the answers.

e Is the Susquehanna River relatively wide or narrow at the water gaps? Why? Why are there no islands in the gaps?

f Are the tops of the ridges roughened more or less than their base by erosion? Which ridge shows least roughening?

g One side of Peters Mountain and of Second Mountain is composed entirely of rock of uniform hardness; the other side of each consists of rock differing in hardness. How can this be determined from the sheet? What is being developed along the base of some of the ridges? Where is this best shown?

h How much slope per mile has Stony Creek on the sheet? (Measure a straight line from the margin of the map to the mouth of the creek and add two miles for windings.) Does the slope of the valleys of the creek on this sheet show that the streams are still deepening their channels? Is it probable that the ridges are being lowered as fast as the valley? Why? How will this affect the relief of this region? When will the height of the ridges above the valleys be greatest? What will the topography afterwards become?

i Many of the creeks have very meandering courses near their mouths and flow in narrow gorges cut a hundred feet in the bottom of broad valleys. Account for these facts. How do you account for the present general topography of this region if at one time after the original folding it was worn down to a nearly level plain?

j What is the average height of the plateau region south of Blue Mountain? Do the contours show that this region is rough or smooth? How does the plan of the wagon roads show this? Why do the railroads usually follow streams in a country like this? What exception is shown? Explain it.

k What mining industries are carried on in this and adjacent portions of the

Alleghany Mountains? What part of the region represented on this sheet is suitable for farming?

l Show by a profile the character of the water gap between Second Mountain and Cove Mountain. Follow the center of each ridge about three miles back from the river. Use only the hundredth contours for data. Make the horizontal scale the same as the sheet and the vertical scale 1 cm. to 500 ft. Make a profile from Powell's Creek southeastward across the ridges, using the following approximate data: Vertical scale of 1 cm. to 500 ft. This will make the ridges about four times too high. On the same base make a profile with a vertical scale of 1 cm. to 2,000 ft., which will give a nearly natural scale.

Stations.	Dist. from Starting Point.	Alt.
Powell Creek	.0 cm.	400 ft.
Peter's Mt.	1.8 "	1300 "
Clark Creek	3.2 "	400 "
Third Mt.	5.6 "	1200 "
Stony Creek	8.0 "	400 "
Second Mt.	9.6 "	1300 "
Fishing Creek	11.8 "	400 "
Blue Mt.	15.0 "	1300 "
Mt. Paxton Creek	17.0 "	500 "

(*2*) To represent the characteristic surface features of this region by a model. Build up a small sand model of the region around Second Mountain and Cove Mountain to show the relative height and width of the water gap and the height of the mountains.

Name——————————————

Address——————————————

Exercise LIII.

A STUDY OF MOUNTAIN TOPOGRAPHY—II.

Material. The Anthracite, Colorado, Sheet of the U. S. G. S. The relief map of the United States used in the previous exercises. Moulding sand.

(*1*) To comprehend the surface features of the Rocky Mountains in comparison with the Appalachians.

Though the Rocky Mountains have no such uniformity of structure as occurs in the Northern Appalachians, their more common forms may be fairly typified by this sheet. The rocks of this region are generally sedimentary and either horizontal or open-folded. They contain some valuable coal beds. The whole region is traversed by many intersecting faults, usually of less than 100 feet displacement. Extensive igneous masses lie between and above the sedimentary formations and usually make the higher mountain masses, such as Mt. Carbon, Mt. Axtell, Anthracite Range, Mt. Beckwith, Storm Ridge, Mt. Marcellina and Gothic Mountain. Dikes are abundant, forming the crests of the Ruby Range and making sharp ridges down the flanks of the mountain and across the valleys. Mt. Emmons, Peeler and Garfield Peaks, Anthracite Mesa and the ridge extending southeast from Schuylkiil Mountain are sedimentary, mostly sandstone and shale.

a Indicate the location of this region on the United States relief map. By aid of a large map answer the following questions: In what part of Colorado is this region? In what direction and how far from Denver is the Anthracite Range? Of what large mountain range is this a part? What river system drains its eastern flank? What its northern? What its southern?

b What scale is used on this sheet? What is its contour interval? Why would not a 20-foot contour interval be suitable for this map?

c Give the length of the Anthracite Range from Beckwith Pass to Ohio Pass. Give its width from Swampy Pass to Anthracite Creek. Give the length of Ruby Range from Anthracite Creek to the north border of the map. Give its width from Anthracite Creek to Robinson Basin.

d What is the age of the streams of this region? Give the characteristics by which they show their age. What marked differences are there between the valleys of Ohio Creek, Oh-Be-Joyful Gulch and Slate River on the one hand and the lower part of Anthracite Creek and Cliff Creek on the other? Which are cutting into igneous and which into sedimentary rock?

e (a) Name four passes and give the altitude of each. (b) Make a profile along the road or creek from Mt. Carbon P. O. to Irwin, having the same horizontal scale as the map and a vertical scale of 500 ft. to 1 cm. May there be any marshy land in a pass? Why?

f Where in general do the wagon roads, trails and railroads run?

g The location of villages is determined largely by the accessibility of workable coal mines. What other features influence their locations? Note particularly Irwin.

h What are the most marked differences between the ridges of this region and those in the Appalachian Mountains you studied as to length, width, height, crest line and general arrangement?

i Which mountain system has been worn down the most? Which is the older of the two systems?

(*2*) To represent the characteristic surface features of this region by a model. Beginning with the Anthracite Range build a sand model on approximately the same scale as you used in Exercise LII. The model should show the relative height of mountains and depth and width of valleys.

Name————————————————

Address————————————————

Exercise LIV.

A STUDY OF A VOLCANO.

Material. The Mount Shasta, California, Sheet of the U. S. G. S. The United States relief map used in the previous exercises.

(*1*) To comprehend the topographic differences between a folded mountain and a volcano.

a Indicate the location of this area on the United States relief map. What scale is used in this sheet? How many square miles are here represented? What is the contour interval on this sheet?

b In what range of mountains is Mount Shasta situated? What is the height of its summit above the sea? Above the Sacramento River? What about the form of the mountain shows it to be of volcanic origin? What is the diameter of the mountain from the Sacramento River to the northeast corner of the map? How does the slope at the top compare with that near the base? Would you imagine this to be an active or an extinct volcano? Why?

c Locate Lava Park. Would the steepness of its sides show the lava which formed it to be thin or thick? Do you think this lava came from the top of Mt. Shasta or from some place in its side? Why? Observe Lava Flow on the western slope. At what height did this lava flow issue from the volcano? Was it thick or thin? The lava flows of which these are types are called coulees and are the most common form of addition to Mt. Shasta. Was the lava which made up the base layers of Mount Shasta more or less fluid than that which made up the top layers? Might any other cause explain the great areas of these lower layers?

d Scattered over the mountain in various places are cinder cones. What is the general shape of these cones? Find the areas of two or three. When the material composing them was sent out was it in a solid or a liquid form? Was the eruption which sent it forth explosive or quiet? Is all the material which builds up a volcano sent forth from the crater? Does the same volcano always send out the same kind of material?

e How far apart do the two summits lie? How much higher is Mt. Shasta than Shastina? Since the glaciers on Shasta extend far below the summit of Shastina why has not Shastina glaciers also? On which side of the mountain are the glaciers largest and most numerous? Can you give any reason for this? Why should the summit of the volcano be free from snow? Why should the surface of the glacier be represented by curved lines? What kind of moraine is represented upon the map?

f How are the mountain streams principally fed? Do you find any other source of supply? Account for the great number of intermittent streams. At what time of the year do the streams carry the most water? Why? Notice the cliff (see legend) between the glaciers. Does it show much or little cutting by the glacier?

g Can you frame a theory to account for the disappearance of Inconstance Creek? Trace Mud Creek from its origin to where it leaves the map. It is turbid and muddy, as its name implies. Squaw Creek to the west is a clear stream. Can you offer any explanation of this difference?

h Construct a profile of Mt. Shasta from west to east with a vertical scale of 1 cm to 5,000 ft. This gives a nearly natural scale.

Distances.	Altitudes.
0 cm.	4000 ft.
1 "	4800 "
2 "	5500 "
3 "	6300 "
4 "	7300 "
5 "	12433 "
6 "	11950 "
7 "	13000 "
7.5 "	14380 "
8 "	12500 "
9 "	9800 "
10 "	8500 "
11 "	7500 "
12 "	6700 "
13 "	5800 "
14 "	5200 "
15.6 "	4000 "

(*2*) To represent the volcanic form of Mount Shasta by a model.

Build a small sand model of Mount Shasta, beginning by building up to the highest portions and moulding the surface features down from this higher altitude to show the relative height and steepness of slope.

Name——————————————

Address——————————————

Exercise LV.

THE LOCATION OF VOLCANOES.

Material. A map showing the location of volcanoes over the earth's surface. An outline map of the earth on Mercator's projection.

(*1*) To study the distribution of active volcanoes relative to new and old mountain systems.

By dots represent the location of all active volcanoes and volcanic regions.

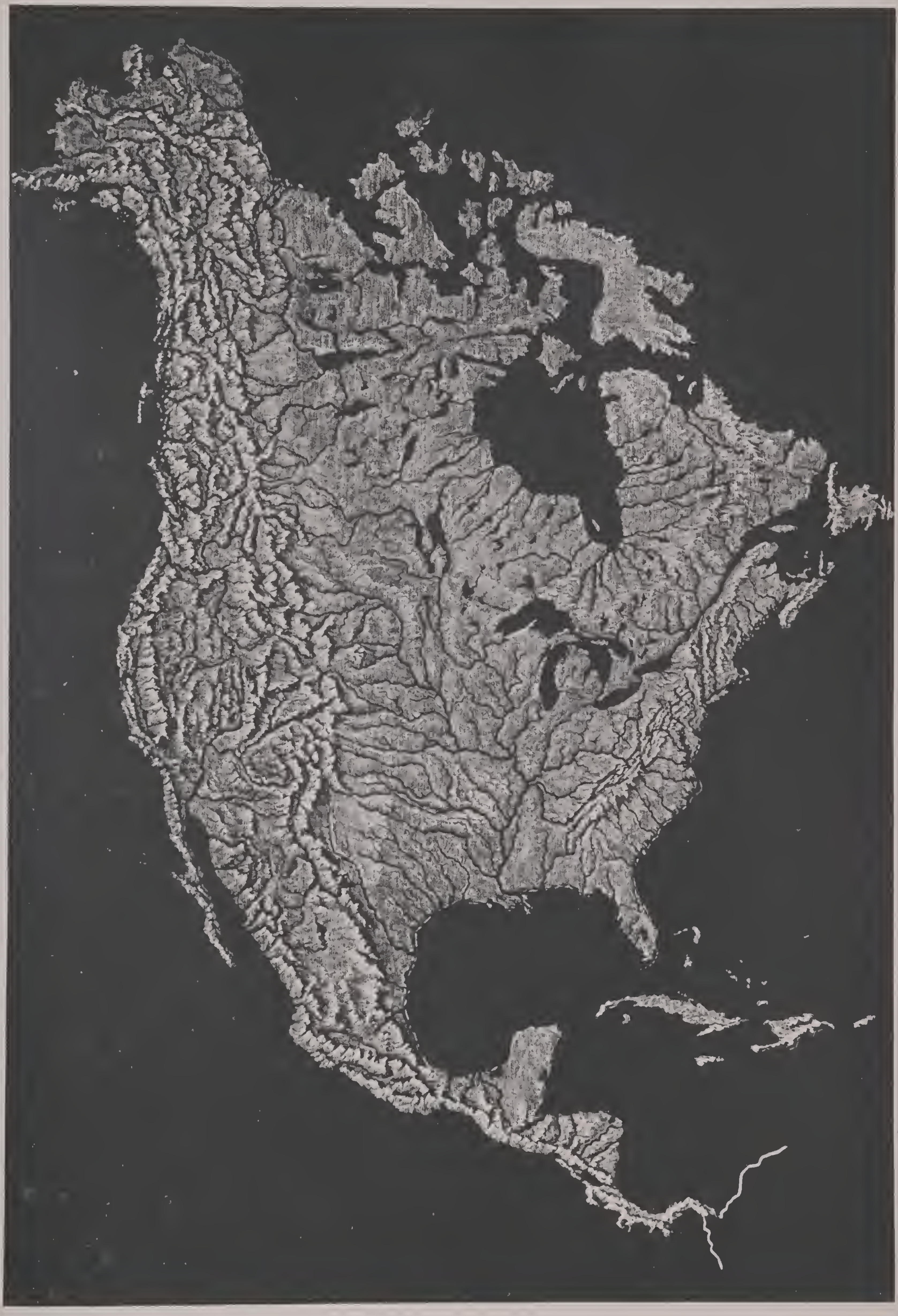
a What is noticeable concerning the location of volcanoes relative to the sea coasts? About what ocean are they most prevalent?

b How are the islands, three hundred miles or more distant from the coasts, formed? Describe the processes by which a volcano might build up an island from the sea floor.

c Are the volcanoes, along the coasts, located in the young or in the old mountain systems? Account for this fact.


LIFE REGIONS OF THE WORLD.
Tropical Forest Areas and Trade Wind Coasts.
Savannas.
Deserts.
Forested Areas of Temperate Zone.
Agricultural Area of Temperate Zone.
Semi-arid Plains of Temperate Zone.
Tundra.
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
NORTH AMERICA
SOUTH AMERICA
EUROPE
ASIA
AFRICA
AUSTRALIA
OCEANIA
GREENLAND
Longitude from Greenwich

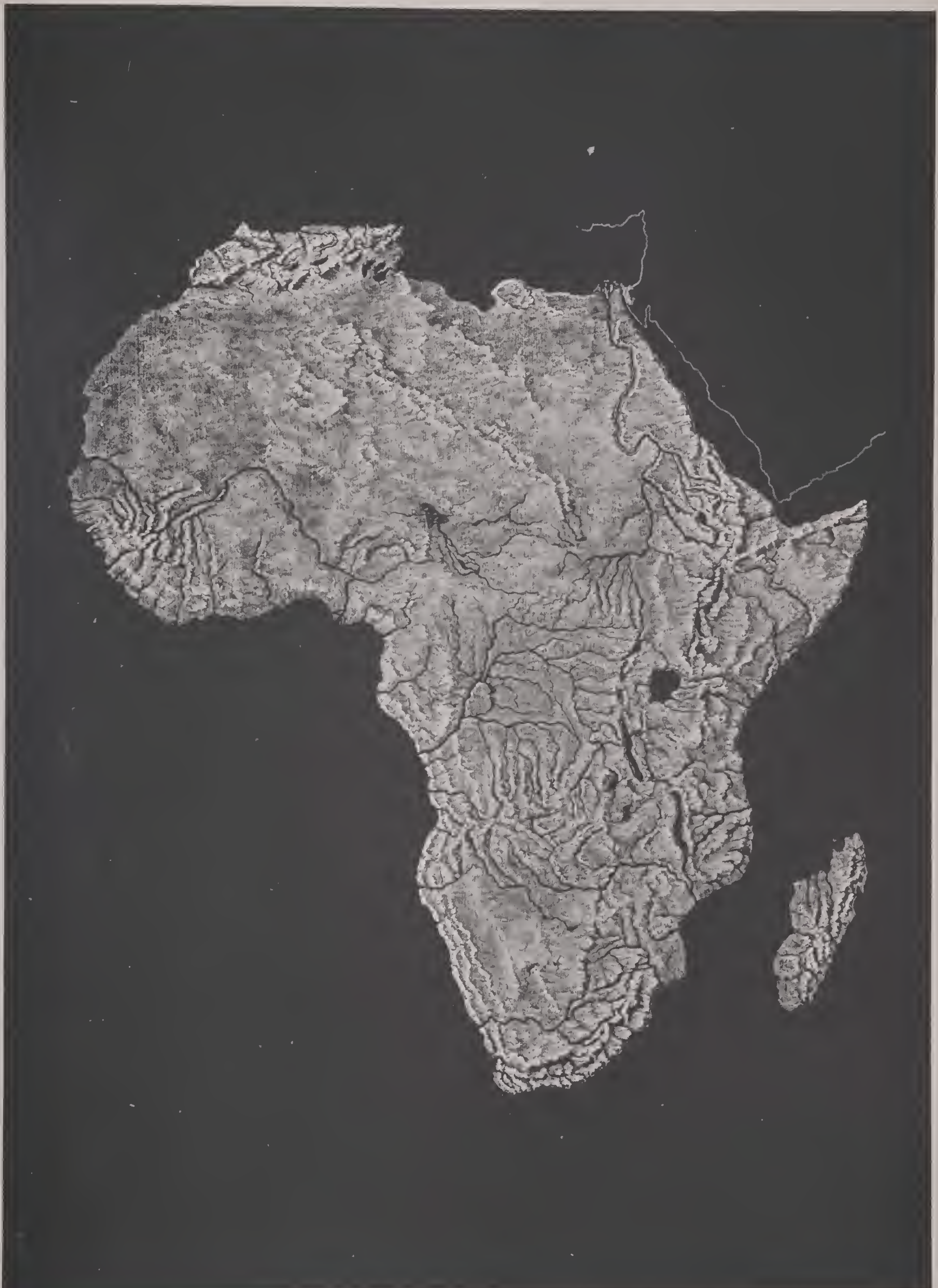
UNITED STATES



 NORTH AMERICA

 SOUTH AMERICA

EURASIA



AFRICA

AUSTRALIA

Atkinson, Mentzer & Grover, Chicago

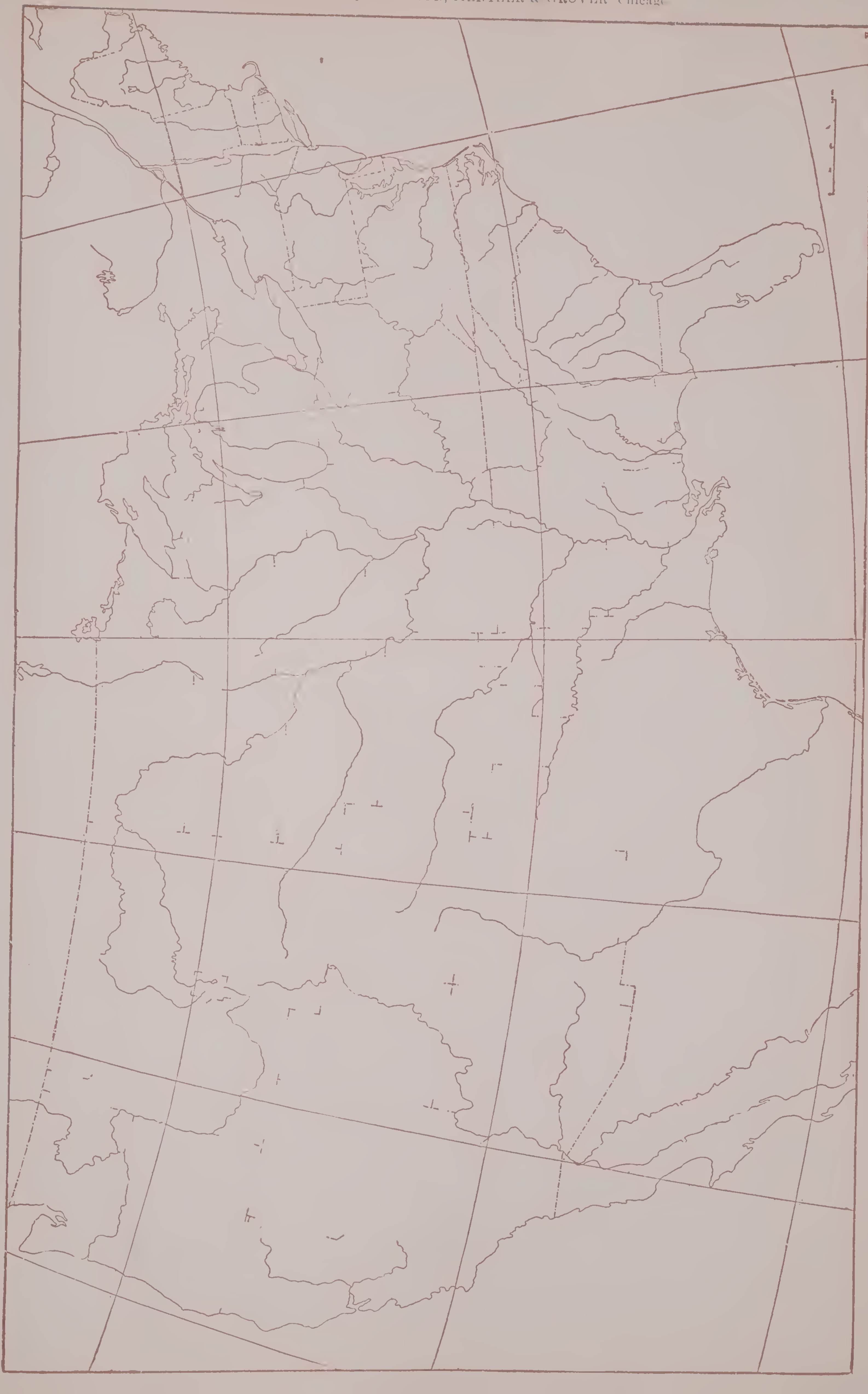
Atkinson, Mentzer & Grover, Chicago

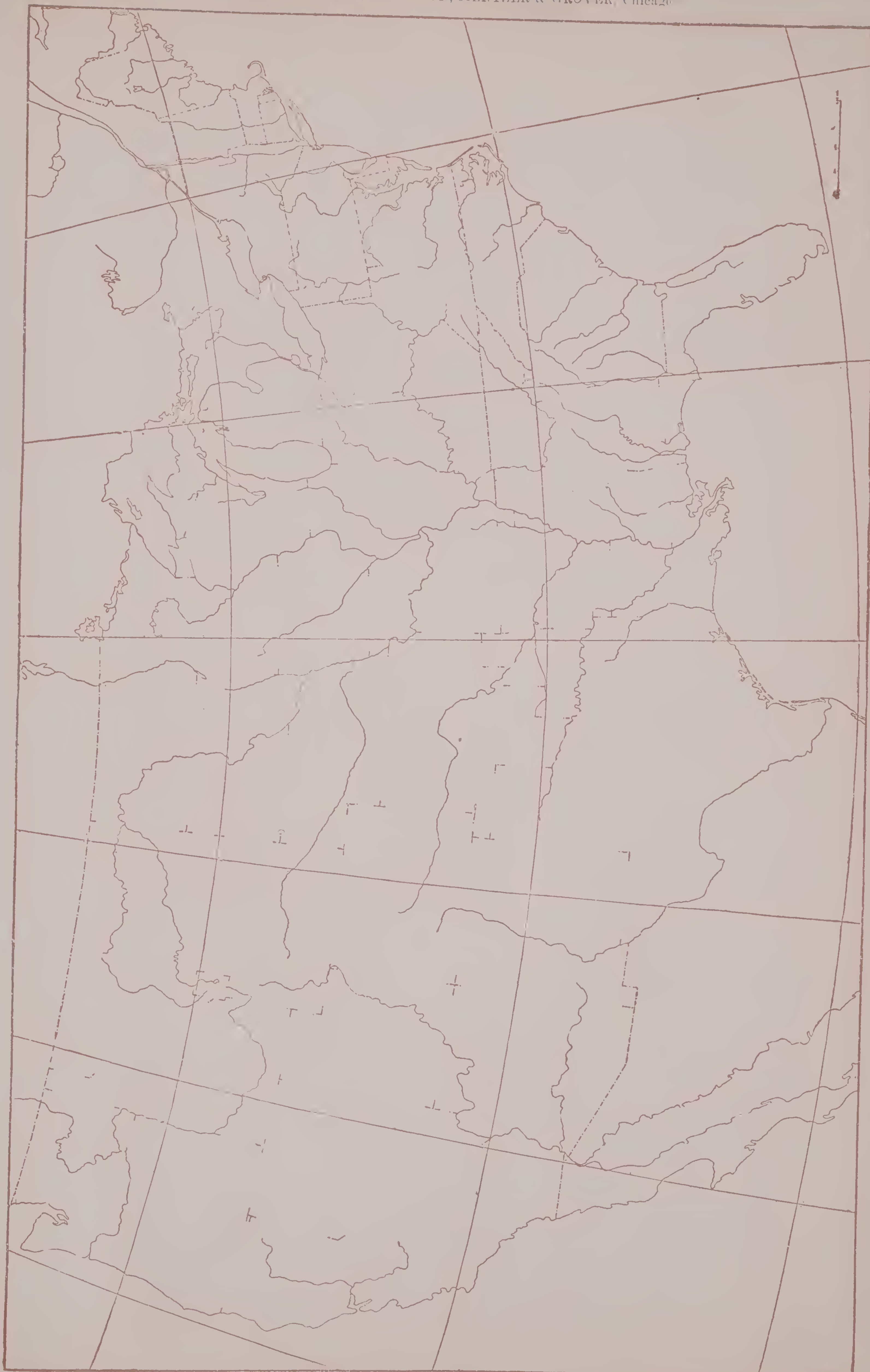
Atkinson, Mentzer & Grover, Chicago

Atkinson, Mentzer & Grover, Chicago

Atkinson, Mentzer & Grover, Chicago

Atkinson, Mentzer & Grover, Chicago





Copyrighted 1905 by ATKINSON, MENTZER & GROVER, Chicago


THE WORLD
ON MERCATOR'S PROJECTION.
Arctic Circle
EQUATOR
Tropic of Cancer
Tropic of Capricorn
Antarctic Circle


Arctic Circle
EQUATOR
Tropic of Cancer
Tropic of Capricorn
Antarctic Circle
THE WORLD
ON MERCATOR'S PROJECTION.


Arctic Circle
Tropic of Cancer
EQUATOR
Tropic of Capricorn
Antarctic Circle
THE WORLD
ON MERCATOR'S PROJECTION.


THE WORLD
ON MERCATOR'S PROJECTION.
EQUATOR
Tropic of Cancer
Tropic of Capricorn
Arctic Circle
Antarctic Circle

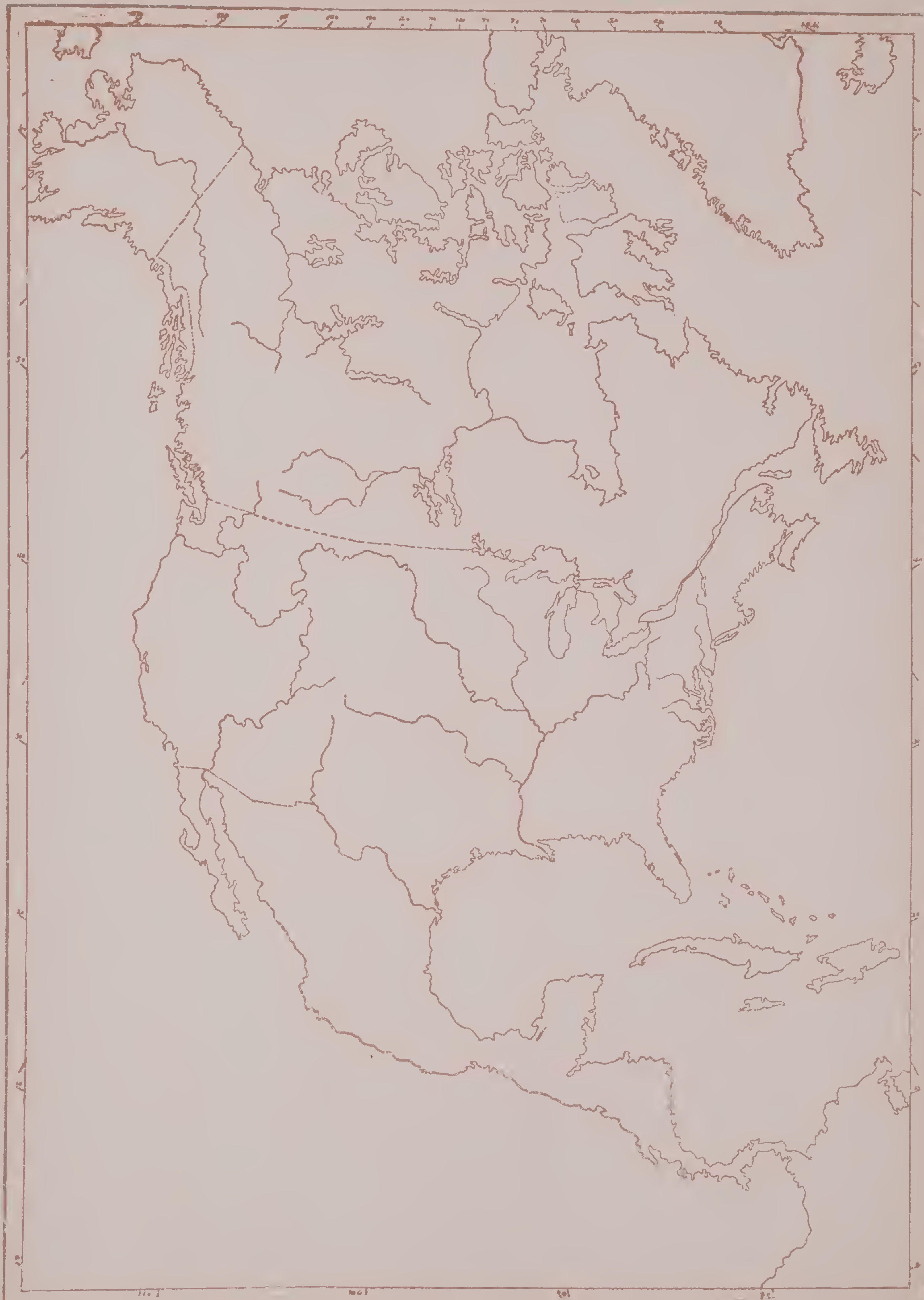

Arctic Circle
Tropic of Cancer
EQUATOR
Tropic of Capricorn
Antarctic Circle
THE WORLD
ON MERCATOR'S PROJECTION.

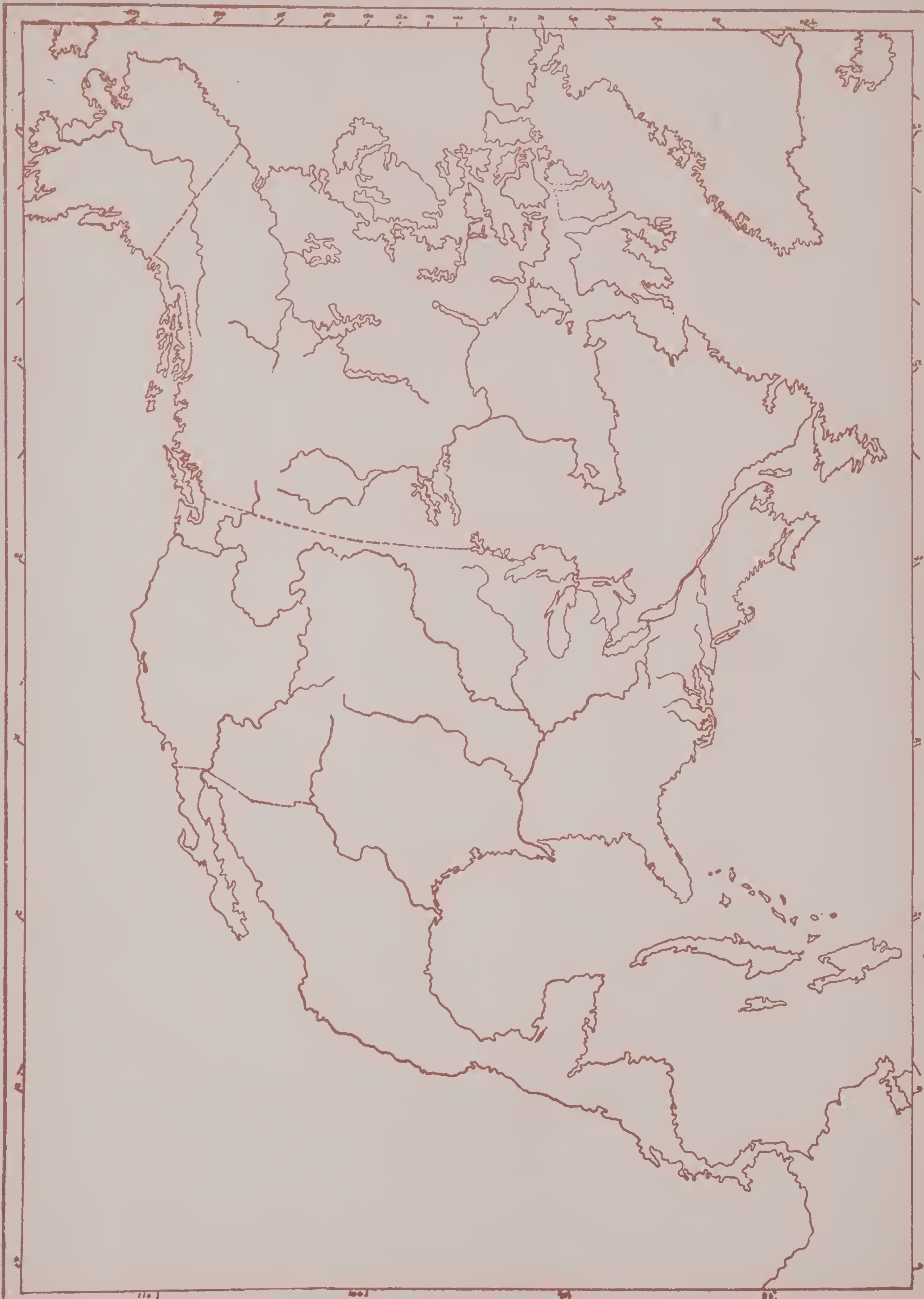

THE WORLD
ON MERCATOR'S PROJECTION.
Arctic Circle
EQUATOR
Tropic of Cancer
Tropic of Capricorn
Antarctic Circle

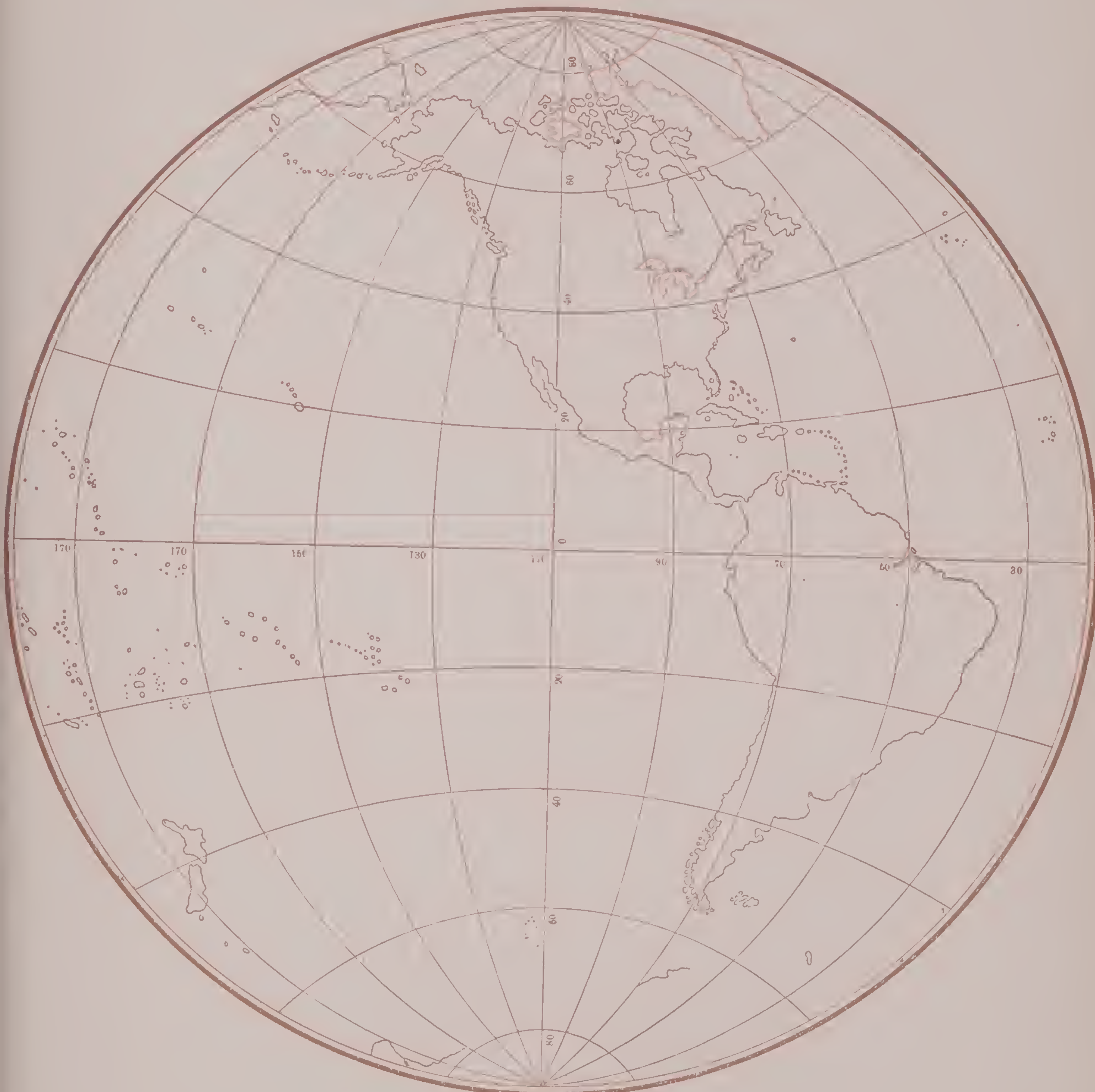

THE WORLD
ON MERCATOR'S PROJECTION.
Arctic Circle
Tropic of Cancer
EQUATOR
Tropic of Capricorn
Antarctic Circle


Arctic Circle
EQUATOR
Tropic of Cancer
Tropic of Capricorn
Antarctic Circle
THE WORLD
ON MERCATOR'S PROJECTION.

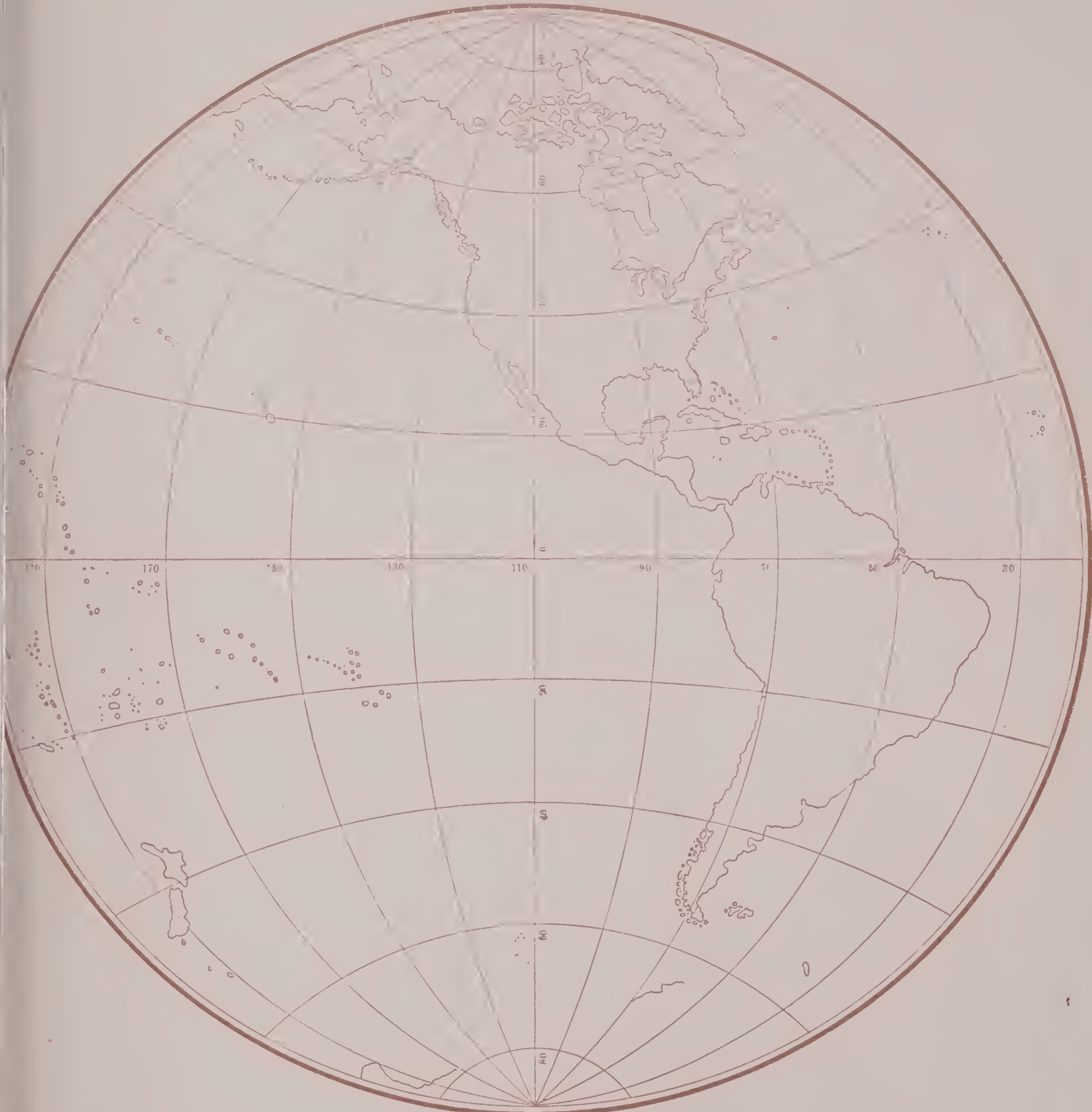

THE WORLD
ON MERCATOR'S PROJECTION.
Arctic Circle
Tropic of Cancer
EQUATOR
Tropic of Capricorn
Antarctic Circle



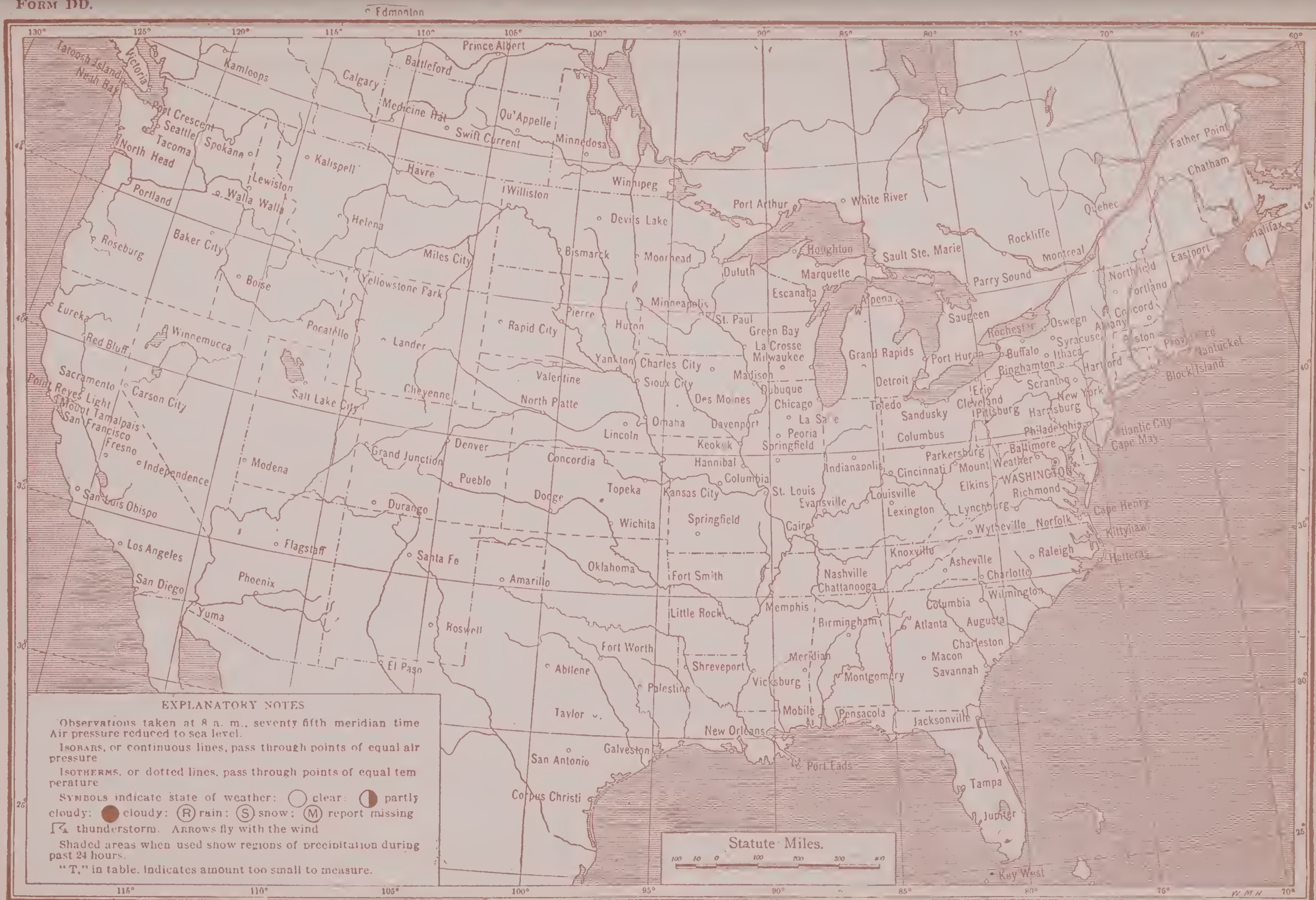



80
60
40
20
0
170
170
150
130
110
90
70
50
30
20
40
60
80


170
170
150
130
110
90
70
50
30
80
60
40
20
0
20
40
60
80


170
150
130
110
90
70
50
30

Form DD.



EXPLANATORY NOTES

Observations taken at 8 a. m., seventy fifth meridian time Air pressure reduced to sea level.

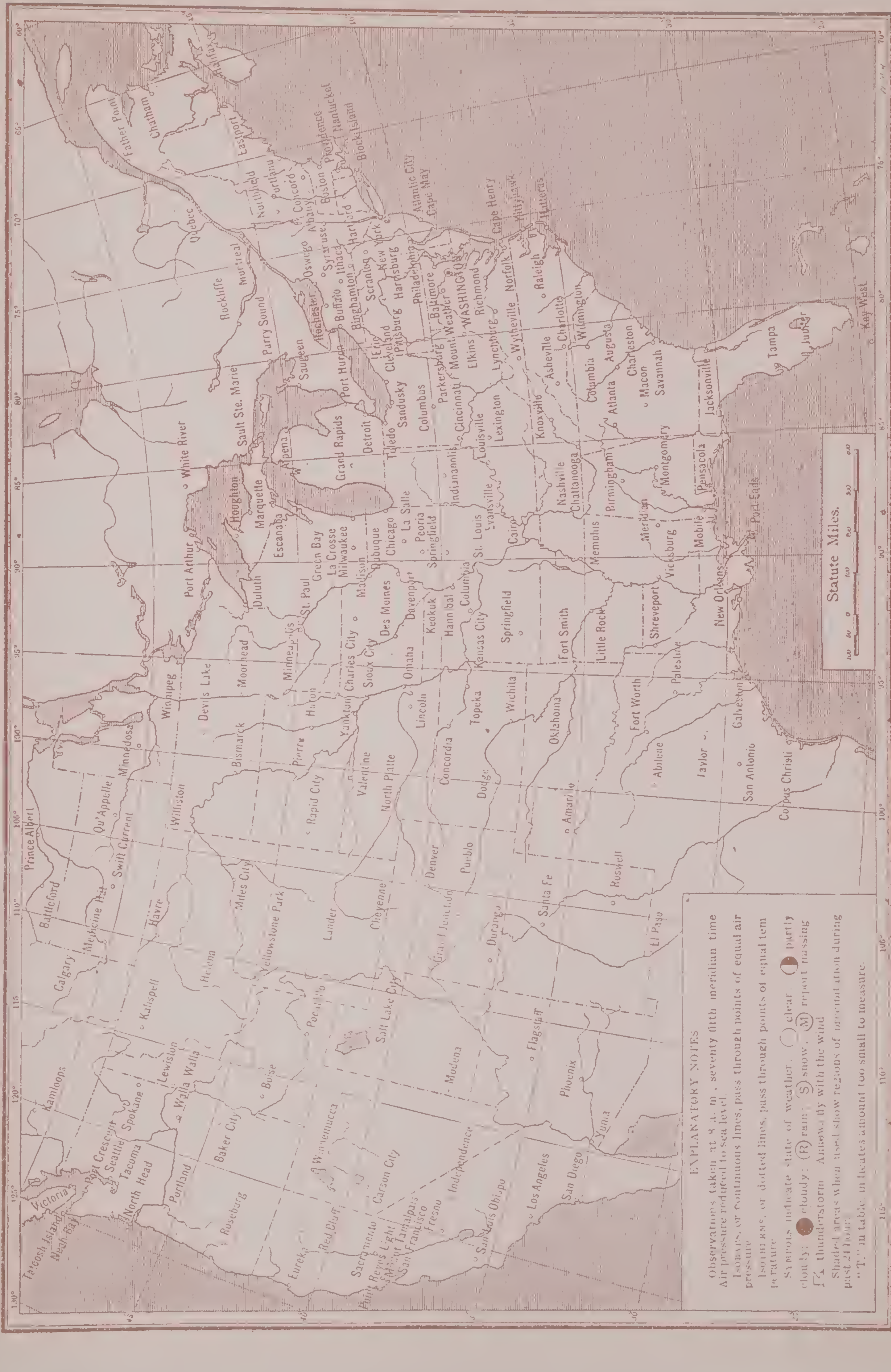
Isobars, or continuous lines, pass through points of equal air pressure

Isotherms, or dotted lines, pass through points of equal temperature

Symbols indicate state of weather: ◯ clear: ◐ partly cloudy: ● cloudy: (R) rain: (S) snow: (M) report missing ↖ thunderstorm. Arrows fly with the wind

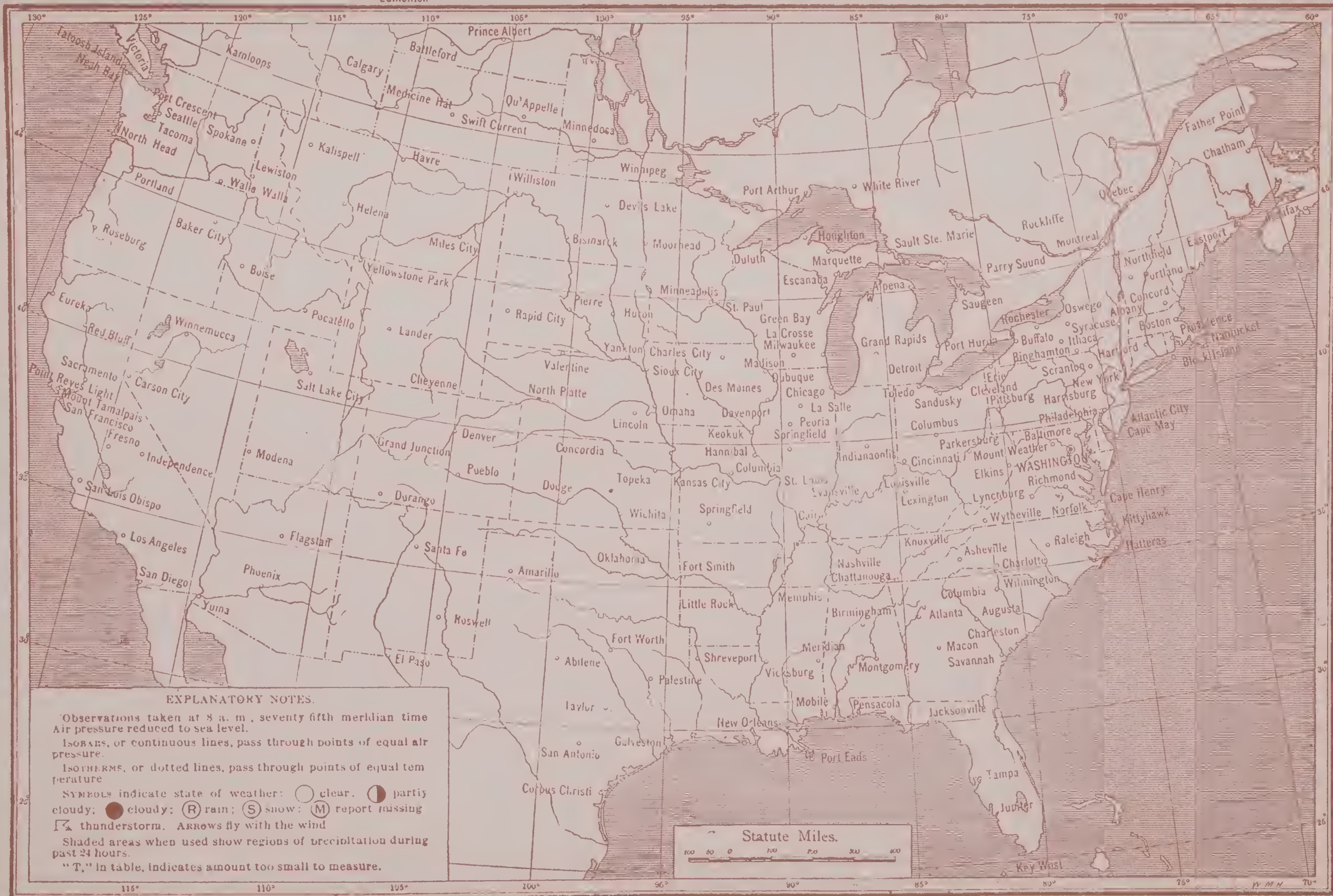
Shaded areas when used show regions of precipitation during past 24 hours.

"T," in table, indicates amount too small to measure.


Statute Miles.
EXPLANATORY NOTES
Observations taken at 8 a. m., seventy fifth meridian time
Air pressure reduced to sea level.
Isobars, or continuous lines, pass through points of equal air pressure
Isotherms, or dotted lines, pass through points of equal temperature
Symbols indicate state of weather. clear. partly cloudy; cloudy; (R) rain; (S) snow; (M) report missing
thunderstorm. Arrows fly with the wind
Shaded areas when used show regions of precipitation during past 24 hours
"T." in table indicates amount too small to measure.

FORM DD.

FORM DD.



EXPLANATORY NOTES.

Observations taken at 8 a. m., seventy fifth meridian time Air pressure reduced to sea level.

ISOBARS, or continuous lines, pass through points of equal air pressure.

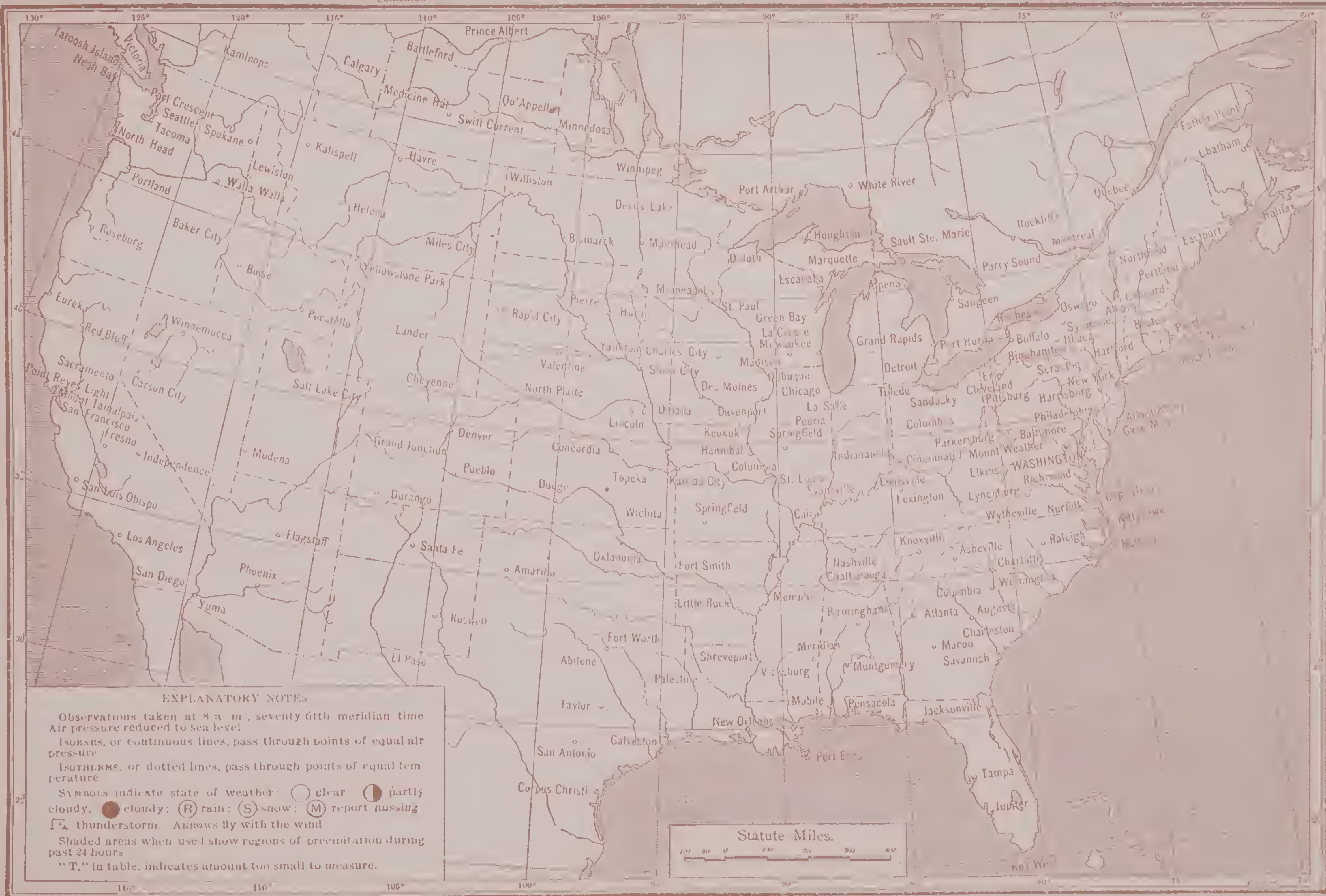
ISOTHERMS, or dotted lines, pass through points of equal temperature

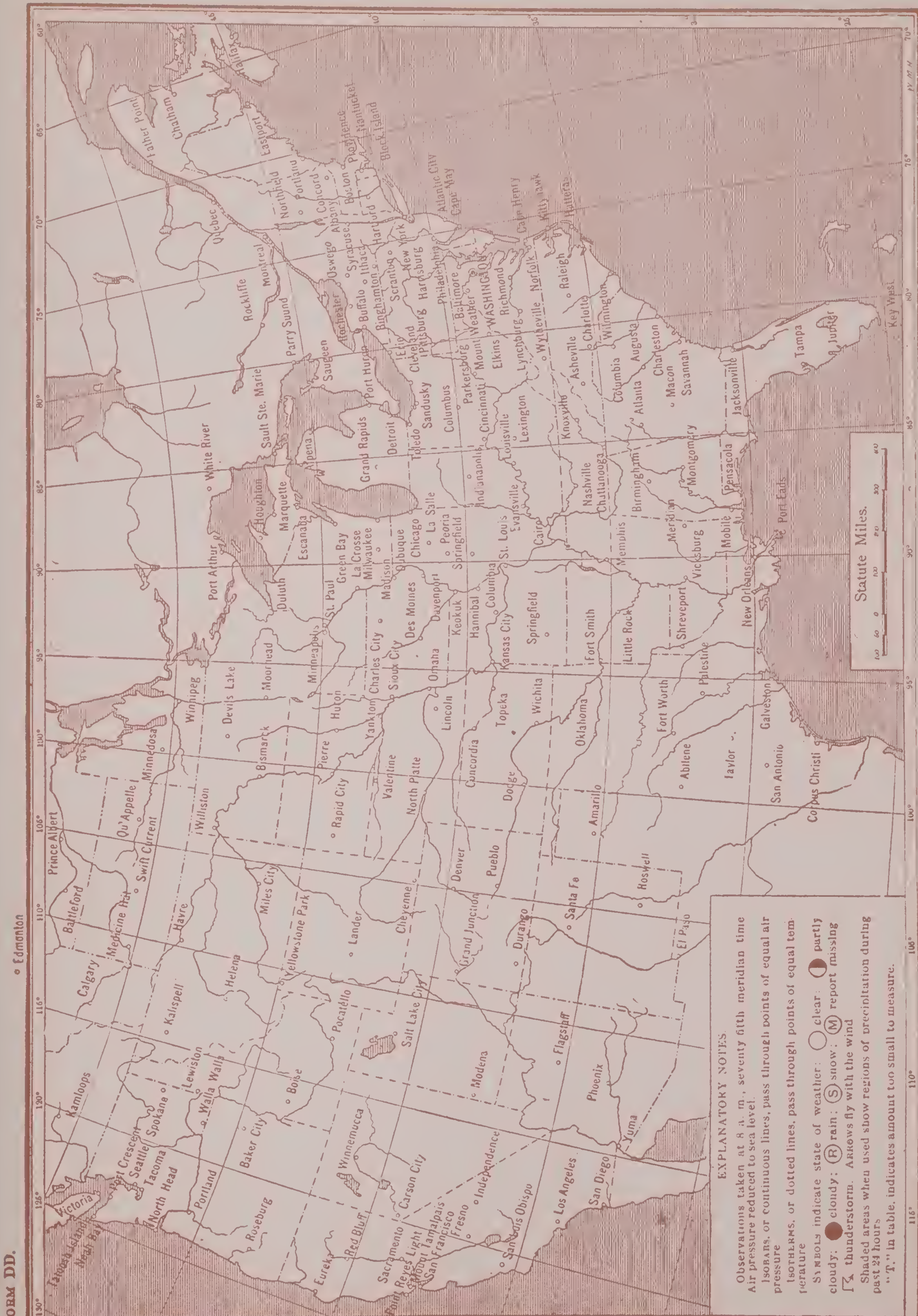
SYMBOLS indicate state of weather: ◯ clear. ◐ partly cloudy; ● cloudy; Ⓡ rain; Ⓢ snow; Ⓜ report missing ↱ thunderstorm. ARROWS fly with the wind

Shaded areas when used show regions of precipitation during past 24 hours.

"T," in table, indicates amount too small to measure.

FORM DD.


Edmonton
Prince Albert
Battleford
Calgary
Kamloops
Tatoosh Island
Neah Bay
Victoria
Port Crescent
Seattle
Tacoma
North Head
Spokane
Kalispell
Medicine Hat
Swift Current
Qu'Appelle
Minnedosa
Havre
Williston
Winnipeg
Lewiston
Walla Walla
Portland
Helena
Baker City
Roseburg
Miles City
Boise
Yellowstone Park
Bismarck
Devils Lake
Moorhead
Duluth
Port Arthur
White River
Houghton
Marquette
Sault Ste. Marie
Escanaba
Alpena
Parry Sound
Rockliffe
Montreal
Quebec
Father Point
Chatham
Halifax
Eastport
Northfield
Portland
Eureka
Red Bluff
Winnemucca
Pocatello
Lander
Rapid City
Pierre
Huron
St. Paul
Green Bay
Saugeen
Oswego
Albany
Concord
Boston
Sacramento
Point Reyes Light
Mount Tamalpais
San Francisco
Carson City
Salt Lake City
Cheyenne
Valentine
North Platte
Yankton
Charles City
Sioux City
Madison
Milwaukee
Grand Rapids
Port Huron
Buffalo
Ithaca
Binghamton
Hartford
Fresno
Independence
Modena
Grand Junction
Denver
Lincoln
Omaha
Des Moines
Dubuque
Chicago
La Salle
Peoria
Springfield
Davenport
Detroit
Toledo
Sandusky
Erie
Cleveland
Pittsburg
Scranton
New York
Harrisburg
Philadelphia
Atlantic City
San Luis Obispo
Pueblo
Concordia
Keokuk
Hannibal
Columbia
Indianapolis
Columbus
Cincinnati
Parkersburg
Baltimore
Mount Weather
WASHINGTON
Elkins
Richmond
Durango
Dodge
Topeka
Kansas City
St. Louis
Evansville
Louisville
Lexington
Lynchburg
Wytheville
Norfolk
Los Angeles
Flagstaff
Santa Fe
Wichita
Springfield
Cairo
Knoxville
Asheville
Raleigh
San Diego
Phoenix
Amarillo
Oklahoma
Fort Smith
Nashville
Chattanooga
Charlotte
Wilmington
Yuma
Roswell
Little Rock
Memphis
Birmingham
Columbia
Atlanta
Augusta
Charleston
Fort Worth
Abilene
Shreveport
Meridian
Macon
Savannah
El Paso
Palestine
Vicksburg
Montgomery
Taylor
Mobile
Pensacola
Jacksonville
New Orleans
San Antonio
Galveston
Port Eads
Corpus Christi
Tampa
Jupiter
Key West
Statute Miles.
EXPLANATORY NOTES
Observations taken at 8 a. m., seventy fifth meridian time Air pressure reduced to sea level
ISOBARS, or continuous lines, pass through points of equal air pressure
ISOTHERMS, or dotted lines, pass through points of equal temperature
SYMBOLS indicate state of weather: clear; partly cloudy; cloudy; (R) rain; (S) snow; (M) report missing; thunderstorm. ARROWS fly with the wind
Shaded areas when used show regions of precipitation during past 24 hours
"T," in table, indicates amount too small to measure.


FORM DD.
EXPLANATORY NOTES
Observations taken at 8 a. m., seventy fifth meridian time Air pressure reduced to sea level.
ISOBARS, or continuous lines, pass through points of equal air pressure
ISOTHERMS, or dotted lines, pass through points of equal temperature
SYMBOLS indicate state of weather: clear; partly cloudy; cloudy; R rain; S snow; M report missing
thunderstorm. ARROWS fly with the wind
Shaded areas when used show regions of precipitation during past 24 hours
"T." in table, indicates amount too small to measure.
Statute Miles.

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR.	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR, OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR , OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER,
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER,
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR, OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															
	Mon.															
	Tues.															
	Wed.															
	Thur.															
	Fri.															
	Avg. Wk.															

DATE	DAY	HOUR OF DAY	TEMPERATURE	BAROMETRIC PRESSURE	DRY BULB THERMOMETER	WET BULB THERMOMETER	RELATIVE HUMIDITY	DIRECTION OF WIND	VELOCITY OF WIND	PERCENTAGE OF DAYS CLOUDY	KINDS OF CLOUDS	FORM OF PRECIPITATION	AMOUNT OF PRECIPITATION	FROST, DEW OR CLEAR	SUNSET COLORS HEAVY, LIGHT OR NO COLORATION	POSITION OF STORM CENTER.
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															
	MON.															
	TUES.															
	WED.															
	THUR.															
	FRI.															
	AVG. WK.															